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TRANSACTIONS
OF THE
BOTANICAL SOCIETY OF EDINBURGH

SESSION CXXIII

PRESIDENTIAL ADDRESS.

11th May 1959.

The Royal Botanic Garden and the University Department of Botany, Edinburgh.

H. R. Fletcher
(Royal Botanic Garden, Edinburgh).

I have thought fit in this address to endeavour to tell you something of the history of the Royal Botanic Garden and of the Department of Botany in the University of Edinburgh and to place this history in scientific and personal relation to the general progress of botanical thought. I believe that the subject is not altogether inappropriate in view of the fact that for nearly a century and a quarter the Botanical Society of Edinburgh has been grafted most admirably on to the Garden and Botany Department. And I believe that the occasion of my endeavour is not altogether inappropriate either, because last year marked the end of an era, for the posts of Keeper of the Garden and Professor of Botany ceased to be vested in the same person as had they been, except for an interval of 33 years, since 1670.

Although the Royal Botanic Garden, Edinburgh, was founded in 1670 as a Medicinal Garden, in an endeavour to improve the training of the medical man and to give him an accurate knowledge of the plants which would serve as the source of the drugs he would have to compound, it is important to note that at this date the age of the herbalist was drawing to a close and a new era in the study of plants had begun. The year 1670 was a

significant one. It was the year after Robert Morison, the Aberdonian, and the newly appointed first Professor of Botany at Oxford (the Botanic Garden there had been founded in 1632 by Lord Danvers) had published his first botanical work, the *Praeludia Botanica,* in which he had given the rudiments of his system of classification, a classification which in large measure was a revival of Caesalpino's methods of almost a hundred years before, based on the structure of the fruit and seed. It was also the year after John Ray had carried out experiments on the movement of sap in trees and thus was foreshadowing the work of Stephen Hales in the following century. It was the same year in which John Ray published the first survey of the plants of England, *Catalogus Plantarum Angliae,* and there is no doubt but that Morison and Ray, great rivals though they were, at this time were putting systematic botany on the map and that on their work de Jussieu, de Candolle, and Bentham and Hooker were later to build their systems of classification. And it was the year before Nehemiah Grew's first book on Plant Anatomy, *The Anatomy of Vegetables Begun,* was laid before the Royal Society of London on the same day as the Society had received Marcello Malpighi's first manuscript on Plant Anatomy.

In 1670 then, Dr. Andrew Balfour and Dr. Robert Sibbald rented a portion of the Royal Gardens at Holyrood House for the making of a Physic Garden. Balfour had studied medicine in London under the great Harvey, had become deeply interested in Botany after having seen the garden of the Duke of Orleans at Blois, then in the charge of Robert Morison, and on settling in Edinburgh shortly before 1670 had formed a small garden. Sibbald was Balfour's greatest friend and obviously a very remarkable man, for in addition to being the first occupant of the Chair of Medicine in the University, Physician to the King and President of the Royal College of Physicians in Edinburgh, he was also Geographer Royal for Scotland. In Edinburgh, about 1666, he had established a small private botanical museum which gradually became the largest in the country and of which Sibbald compiled a catalogue which the University printed. Their mutual friend was Patrick Murray, Laird of Livingstone, also a botanist and gardener. When Murray died his garden collection of about 1,000 plants came into the hands of Sibbald and Balfour and no doubt this circumstance gave them additional incentive to establish a medicinal garden in Edinburgh. Thus they "obtained

of John Brown, gardener of the North Yards in the Abbey, one inclosure of some 40 feet every way", and the inclosure, together with Murray's plants and some of their own as well, was placed in the care of James Sutherland, "a youth, who, by his own industry, had attained great knowledge of the plants and of medals" (Sibbald's Memoirs). Unfortunately, his interest in numismatics ultimately was to prove his undoing.

Not surprisingly, the Garden, no larger than a modern allotment, soon became too small, and in 1676 a nineteen years' lease was obtained from the Town Council of the Garden attached to Trinity Church and Hospital and of some adjacent ground, and James Sutherland was appointed intendant of this Garden—the Town's Physic Garden. At the same time (1676) Sutherland was made Professor of Botany in the Town's College. The Holyrood Garden—the Royal Garden—was still continued. Thus, in the Valley of the Nor' Loch, and extending from the New Port to the foot of Halkerston's Wynd to near the Orphan Hospital (the site of the present General Post Office) the Physic Gardens flourished for nearly a hundred years. In 1695 the lease of the ground for the Town's Physic Garden at Trinity Hospital, with Sutherland as intendant, was renewed. Likewise was renewed the appointment of Sutherland as Professor of Botany in the Town's College, with a salary of £30 a year. In 1699 he received a further salary—this time from the Crown, ". . . .£50 sterling of yearly pension granted during our pleasure". Round about this time a third Garden was founded in the ground surrounding the College buildings—the College Garden—and Sutherland was placed in charge of this also. Thus early in the 18th Century three Gardens existed in Edinburgh, The Royal Garden (at Holyrood), The Town's (at Trinity House), and The College (at the University)—and James Sutherland was in charge of them all.

There can be no doubt but that Sutherland applied himself diligently to the task of augmenting the collections of plants in the Gardens under his charge. In 1683 he published his "*Hortus Medicus Edinburgensis,* a catalogue of the plants in the Physic Gardens of Edinburgh, containing the most proper Latin and English names". There can also be no doubt that although Sutherland had been the first in Scotland to give systematic expositions of living plants in relation to Materia Medica, he gradually became too interested in coins and medals, and his teaching suffered. In fact, soon after 1700 it came in for such

adverse criticism that in 1705 he resigned his intendantships of the Town's Garden and the College Garden, as well as his Professorship of Botany in the University—although he contrived to hold his charge of the Royal Garden. To the three posts he vacated, Charles Preston was appointed in 1706, to be succeeded by his brother George in 1712.

The date of Sutherland's death is uncertain, but it was probably round about 1714-15, for in the latter year Dr. William Arthur was appointed his successor and a salary of £50 was granted him. Arthur thus succeeded to the office of King's Botanist, Professor of Botany and Keeper of the Royal Garden at Holyrood whilst the quite different appointments of Professor of Botany in the University, intendant of the Town's Garden and of the College Garden were held by the Prestons—until 1738. The Crown, therefore, maintained the teaching of Botany apart altogether from the University and there were thus two rival Schools of Botany in Edinburgh.

During these years botanical events of great significance had been taking place elsewhere. Even five years before the foundation of the Garden, Robert Hooke, onetime assistant to Robert Boyle, had published his great work, the *Micrographia,* and had considerably increased the magnifying power of the microscope. For years Anton van Leeuwenhoek, the Dutch cloth merchant and wine taster, had been devoting his spare time to grinding lenses and making microscopes—and, incidentally, in the process, discovering the pitted vessels of secondary wood, protozoa and bacteria, although of course he didn't recognise them as such. Using the newly invented microscope, Malpighi had been making discoveries in the anatomy and physiology of plants, revealing, among much else, the stomata on leaves and, moreover, understanding their function. Nehemiah Grew had been busy with much the same thing, inventing the term parenchyma, publishing a work on the anatomy of roots in 1673, *The Comparative Anatomy of Trunks* in 1675—the year before Sutherland was appointed Professor of Botany in the Town's College—and in 1682 his *Anatomy of Plants.* The Rev. Stephen Hales, D.D., had become perpetual Curate at Teddington (he was the friend and neighbour of Pope) and had begun the experiments in plant physiology and on animals which were to lead to his becoming a Fellow of the Royal Society in 1718, and to the publication of his *Vegetable Staticks* in 1727. Thus were the sciences of plant

anatomy and of experimental plant physiology being pioneered. John Ray had been further advancing a system of classification, and published his *Historia Plantarum* (1686-1704) wherein, to some extent, he recognised natural affinities in their broader features. And Rudolph Camerarius in Tübingen had been experimenting with Mulberry Trees, Dog's Mercury, Castor Oil and Maize, and had discovered sex in plants.

Such was the botanical climate in 1716 when Charles Alston succeeded Dr. William Arthur who had reigned for less than a year, during which time he had been one of the leaders in the Jacobite plot to capture Edinburgh Castle in 1715, and when this had failed had fled to Italy where he died the following year from a surfeit of figs.

Alston apparently was a botanist of some repute, and had studied in Leyden under Boerhaave. There can be no doubt but that the most important event during his Edinburgh regime of 44 years occurred in 1738 when the Keeperships of the Royal Garden with Crown Professorship and of the Town's Garden with University Professorship (the College Garden having fallen into disorder in 1724 and having been turned to other uses) again became vested in the same person (Alston) as had they been in 1705 and as they were to be for the next 220 years.

The years during which Alston was in Edinburgh practising medicine, and holding the Chair of Botany and Materia Medica and thereby giving two courses of lectures a year, were tremendously important ones in the history of botany in Britain. Stephen Hales, of course, was continuing his physiological researches. Botany in the Universities was making great progress for a Chair of Botany was established in Cambridge in 1724, and at Oxford Jacob Dillenius was appointed to fill the new Chair endowed by Sherard in 1734. Under the guidance of Philip Miller, the Chelsea Physic Garden, which had been founded in 1673 by the Apothecaries Company of London, was making great headway. Miller had been appointed Gardener in 1722 and was receiving rare and often new species of plants from the Cape, Siberia, North America, and the West Indies to the extent that the Garden was said to exhibit the treasures of both the Indies. Ray's system of classification was being overthrown and replaced by the sexual system of Linnaeus which grouped plants according to the number and arrangement of their stamens and styles.

Alston was a most bitter opponent of the sexual system (it is for this that he is most noted) for the very obvious reason that he strongly denied the existence of sex in plants. He went to a great deal of trouble to try to prove that stamens were not necessary for the development of fertile seeds and gave examples of seed production when the application of pollen had not been possible. It would almost seem that Alston was fully aware of the condition which was to puzzle botanists for generations to come—until in fact the explanation of apogamy was supplied.

But in spite of Alston, the sexual system was to triumph. To John Hill, herbalist, gardener, actor, dramatist, poet, novelist, journalist, doctor, and finally vendor of quack medicines, falls the credit for introducing the sexual system into England in his *Flora Britannica* of 1760, and eight years later the system was adopted in the 8th edition of Philip Miller's *Gardener's Dictionary*.

From Alston's *Dissertation on Botany* of 1754 it is clear that anatomical matters were of some interest to him. At the same time it is surprising and certainly disappointing to realise that although he was a close correspondent of Stephen Hales and obviously must have known of the latter's work, he seems not to have appreciated its importance. From the fact that Alston's teaching was strongly biased to Materia Medica as well as from his two-volume work on Materia Medica, it is also quite clear that botany in Edinburgh at this time was still nothing more than the handmaid of medicine.

In 1761 Alston was succeeded by one of his students, John Hope, who became King's Botanist, Keeper of the Royal Garden and Professor of Botany and Materia Medica under the Crown, being paid a salary of £50 "during our pleasure", as well as Keeper of the Town's Garden and Professor of Medicine and Botany in the University. He was the son of an Edinburgh surgeon, a graduate in medicine of Glasgow in 1750, and had studied botany under Bernard de Jussieu in Paris. With his appointment a new botanical era in Edinburgh was initiated.

Hope was very much under the influence of the work of Hales and Duhamel and, realising full well that botanical matters were no longer specially related to medicinal plants, he was instrumental in arranging, in 1768, for the separation of the teaching of Botany from Materia Medica, retaining for himself the Chair of Botany and helping to create a new Chair of Materia Medica of

which Dr. Francis Home was made the first Regius Professor—but without a salary.

The Commission which Hope received from the Crown on 2nd May 1768 reveals two interesting points regarding his appointment. First, this Commission for the first time makes the Crown Professorship of Botany *in the University*. Second, the office of King's Botanist and Keeper of the Garden is made a life appointment with a salary of £50.

Under Hope, for the first time in Edinburgh, there was an active interest in Plant Physiology, Hope experimenting on such problems as growth in length and in width, the effects of light and of gravity, movement of sap and healing of wounds. Moreover, Hope encouraged his Principal Gardener, John Williamson, to do likewise, as a manuscript of Williamson's called "A narrative of experiments made on trees in the Botanic Garden", which is in the Library of the Royal Botanic Garden, well shows. This was an age of experiment in Edinburgh. It was also an age of experiment elsewhere, for in 1774 Priestley discovered oxygen and in 1779 he demonstrated conclusively that plants in sunlight give off oxygen. Moreover, in this same year of 1779 John Ingen-Housz, who had recently come to England from Vienna and knew of Priestley's results, carried out 500 experiments and published *Experiments on Vegetables,* in which the processes of respiration and assimilation were clearly distinguished and defined.

Hope's experiments were seen by, and explained to, his students. Whenever possible his lectures were illustrated by living material and when living material was not available, by diagrams. The students dissected flowers (they were told to bring dissecting needles for this purpose) and seeds (as to-day, they were given bean seeds soaked in water). Hope was thus conducting practical demonstrations in Edinburgh in the 1770's and this is of considerable significance in view of what was to happen in South Kensington a hundred years later.

Apart from Physiology, Hope's other great interest was in Systematic Botany and he was as strong an advocate of the Linnaean System as Alston had been an opponent. He encouraged his students to explore and investigate the flora of Scotland and annually gave a gold medal for the best student's herbarium. There can be no questioning the fact that Hope and his students were the pioneer investigators of the Scottish Flora, for from

certain of Hope's notebooks which are in our Library it is quite clear that he and his students collected widely in Scotland, not only on the mainland but in Arran, Skye, Mull, Orkney and Shetland as well, and Hope, without doubt, greatly influenced Lightfoot when the latter was planning the itinerary of his visit to Scotland in 1772. Neither can there be any questioning the fact that Hope and his student colleagues had collected quite a number of Scottish plants long before they had been found by others and published as new records for the Scottish or British Flora.

From the point of view of the history of the Garden, Hope's greatest achievement lay in uniting the Royal Garden with the Town's Garden and in transferring the combined Garden in 1763 to a new site—at that time more congenial—a site just below where now stands Haddington Place in Leith Walk. Equally important is the fact that he also succeeded in obtaining from the Crown a permanent income for the new Garden—an action which has greatly influenced botanical education in Scotland.

Hope and his Principal Gardeners, first Williamson and then Malcolm McCoig, carefully and thoroughly developed the new five-acre garden in Leith Walk, and in this Garden Hope performed his physiological experiments. Two reminders of Hope's great work as Keeper of the Garden and Professor of Botany are with us to-day in the present Garden—the plaque in memory of John Williamson which he had made in 1781 and the monument to the memory of Linnaeus which he erected in 1778.

Hope was succeeded in 1786 by Daniel Rutherford, the uncle of Sir Walter Scott, and the terms of his appointment are interesting. On November 25th 1786, he was made Professor of Medicine and Botany in the University—by the Town Council. On December 20th 1786, he was made Regius Professor of Botany in the University, Keeper of the Botanic Garden and King's Botanist with "the salary, £50 sterling money, to commence from the 25th day of November last, the day on which the said Dr. Daniel Rutherford was elected to a Professorship in the said University by the Lord Provost, Magistrates and Council of the City of Edinburgh" (Register of Privy Seal of 1786). For the first time the Crown appointed as its Professor and Keeper of the Royal Garden the man who already held the office of Professor in the University and it is the only instance, I believe, in which reference

is made in the Commissions to the appointment made by the Lord Provost and his colleagues.

The appointment of Rutherford was not a happy one. In the first instance Rutherford was not a botanist; he was really a chemist, and was anxious to succeed Joseph Black, the discoverer of CO_2, as Professor of Chemistry. Strangely enough, he who was appointed to Black's Chair was deeply interested in botany and would very much have liked to have succeeded Hope—for the man in question was Hope's own son—Thomas Charles Hope! Rutherford seems to have been interested in plants only as objects for experiments on the chemistry of the atmosphere. He held office until 1819—a period of 23 years during which time far-reaching advances were made in the world of botany in England and elsewhere.

In England Sir Joseph Banks was President of the Royal Society during the whole of Rutherford's reign and was largely dictating British botany. He was also unpaid Director of Kew (founded in 1759) during the whole of this period, was formulating the policy of close collaboration with the Empire which has since been followed at Kew, and was sending out collectors to bring back new plants for the Gardens and Herbarium. The Linnaean Society had been formed in 1788, two years after Rutherford's appointment, and in 1805 Robert Brown, having just returned in the "Investigator" from the Flinders Expedition to Australia, was appointed Librarian to the Society, a post he held until 1822.

In 1810 the first volume of Brown's beautiful work, the *Prodromus Florae Novae Hollandiae,* was published. The other great taxonomic works of this period were Curtis' *Botanical Magazine,* the first volume of which appeared in 1793, three volumes of the *Flora Graeca* of Sibthorpe and Smith, and the 36 volumes of Sowerby & Smith's *English Botany*—the beautiful illustrations by Sowerby and the letterpress the work of James Edward Smith, and the basis for all future work on the British flora—which appeared between the years 1790-1814.

Experimental work there also was. Thomas Andrew Knight, disciple of Hales and Duhamel and one of the keenest students of Plant Physiology and of Horticulture, was publishing in the Philosophical Transactions of the Royal Society of London. His *Observations on the Grafting of Trees* of 1795 discusses inheritance of decay among fruit trees and the propagation of

debility by grafting. His *Experiments on the Fecundation of Vegetables* of 1799 discusses experiments with peas (begun in 1787) which quite clearly show that Knight was observing dominance, recessive behaviour and heterosis almost 80 years before Mendel's day. Knight's great paper *On The Direction of the Radicle and Germen during the Vegetation of Seeds,* read before the Royal Society in 1806, describes the influence of gravitation and centrifugal force on the responses of seedlings. So much for England.

In France Antoine Laurent de Jussieu was publishing his *Genera Plantarum* (1789) in which is embodied his system of classification according to natural affinities, a system which is a development of that of the uncle, Bernard de Jussieu; Christian Hendrick Persoon was publishing the first reliable systematic account of the Fungi—*Synopsis Methodica Fungorum* (1801)—on which future workers were to build. In Berlin there were Sprengel, Willdenow and Humboldt; Sprengel (*Das entdeckte Geheimniss,* 1793) explained the structure of flowers, showing that cross pollination was the rule rather than the exception and distinguishing anemophily from entomophily; and Willdenow and Humboldt pioneering the scientific study of plant geography. In Geneva, de Saussure, building on the work of Ingen-Housz and publishing important discoveries in plant nutrition in his *Recherdes chimiques sur la Végétation* of 1804, was laying the foundation for the future work of Boussingault, Liebeg and Sachs.

But in Edinburgh botanical science was not moving forward under the impetus which Hope had given it. Whether Rutherford was conscious of the progress in botanical thought elsewhere I do not know. But his teaching apparently showed no new development and apparently he did not go out of his way to encourage field botany among his students as Hope had done. Possibly the reason for this was that he suffered from gout and therefore did not find it easy to get around. Still, field botany and the exploration of the Scottish flora did prosper and were prosecuted vigorously by Rutherford's Principal Gardeners, especially John MacKay, brother of James Townsend MacKay who did so much for the Irish flora, and of course by the illustrious George Don. Rutherford, by the way, had five Principal Gardeners during his 23 years in the Leith Walk Garden; Robert Menzies, the elder brother of the distinguished botanist and

traveller Archibald Menzies; MacKay; Don; Thomas Sommerville who died at the young age of 27; and William McNab.

Not only did botany not prosper in Edinburgh; neither did the Garden in Leith Walk during the greater part of Rutherford's tenure of office. It is true that Rutherford had little luck with the first four of his Principal Gardeners. There is no record that Robert Menzies made any important contribution to the Garden. John MacKay, who was tremendously interested in the Scottish flora, was a delicate man who died at the early age of 30 after only two years in office. George Don, in office for four years, obviously could have had little interest in the Garden for he was often away for weeks at a time exploring the Scottish flora. Of Sommerville, who also held the post only for four years, there is some slight evidence that had he lived he would have developed the Garden considerably. This ultimately was done through the energies of William McNab who came from Kew, on the recommendation of Sir Joseph Banks, to succeed Sommerville in 1810, at a salary of £50 a year (he refused to come for the £40 of salary which was originally offered). McNab threw himself wholeheartedly into his work, straightaway began to introduce into the Garden many rare plants which had not previously been cultivated in Edinburgh, and in two years had built up the collection to over 4,000 species belonging to at least 1,000 genera.

Of the Garden at this time there is an interesting description in Patrick Neill's account of Scottish Gardens and Orchards published in 1812 in Sir John Sinclair's *General Report of the Agricultural State and Political Circumstances of Scotland.* There were two collections of hardy herbaceous plants, one arranged according to the Linnaean system, the other according to the system of de Jussieu; there was a collection of Materia Medica plants; there was a collection of shrubs; there were also fine specimens of the Huntingdon willow (*Salix alba*) which had grown from the stakes which John Hope had used to mark out the area of the Garden in 1763; there was a stove containing what was said to be the finest specimen in Britain of the Dragon's-blood tree, *Dracaena draco,* 30 ft. high and which Hope had planted; there was a small house occupied solely by a plant of the Camphor Tree, *Cinnamomum camphora*; there were large specimens of the Date Palm and of *Cycas circinalis;* there were five species of *Banksia* which had been described only in 1811; there was a col-

lection of tender aquatics including *Euryale ferox;* and a collection of hardy aquatics grown in a pond in front of the Conservatory.

The aquatics, the Banksias—and much else— had been introduced by McNab in the last two years. In the following years he continued to amass a great deal of new material and by 1820 the collections were so large that the five-acre Garden could not accommodate them properly; moreover, the glasshouses were in a dilapidated condition and the ground surrounding the Garden, mostly occupied by Nurseries, was in process of being over-built. Consequently almost the first task of Robert Graham when he succeeded Rutherford in 1820 was to transfer the Garden to a new 14 acre site, recently purchased by the Crown, the site it at present occupies in Inverleith. The task of transporting and successfully transplanting well-established trees and shrubs could not have been an easy one. McNab was not deterred however; he invented a machine specially for the purpose and the business took the best part of three years. In the Garden to-day the great Yew which stands near the Western end of the Terrace was one of the plants he moved from Leith Walk; it is also one of the plants which was moved to Leith Walk, from the old Physic Garden, in 1767, by Hope and Williamson. The results of this great transplanting experience McNab later embodied into an important paper—*The Planting and General Treatment of Hardy Evergreens*—which was published in 1830. McNab's other valuable contribution to botanical and horticultural literature was his paper of 1832 on the *Propagation, Cultivation and General Treatment of Cape Heaths,* a group of plants which he grew with remarkable success in the new Garden. By this time McNab certainly was among the foremost horticulturists in the land and his salary had been increased by two instalments to £100. In 1834 a further advance was made to £150. And in this same year of 1834 a Palm Stove was opened, the largest house of its kind in Britain, built at a cost of upwards of £1,500. This is our present day Tropical Palm House with certain modifications made later by Bayley Balfour.

Graham came to Edinburgh, at the increased salary of £100, from Glasgow where he had occupied the first Regius Chair of Botany since its inception in 1818, the same year in which was established, by Royal Charter, the Botanic Garden in Glasgow. Graham's successor in Glasgow was William Hooker, who so in-

creased the stature of the Garden that 20 years later, when a Director had to be appointed to the Royal Gardens at Kew, the post was offered to him. Before Graham was appointed to Edinburgh it was suggested to James Edward Smith, who five years previously had finished the letterpress of *English Botany,* that he should be interested in succeeding Rutherford. But he wasn't. Robert Brown was also approached, Brown who still was Librarian to the Linnaean Society and was about to enter the house in Soho Square which Sir Joseph Banks had left to him. It is an intriguing thought as to what might have happened to botany in Edinburgh if Brown had succeeded Rutherford; intriguing too, the thought as to what Brown's future work might have been had he come to Edinburgh. Brown, however, was unwilling to sever the Banksian connection; instead of returning to the land of his birth (he had been born in Montrose in 1773) he stayed with the Linnaean Socety, later was made the first Keeper of the Botany Department in the British Museum, and during the twenty-five years during which Graham in Edinburgh was practising medicine, teaching in the Hospital, teaching botany, confining his research to Systematic Botany and describing new species for the Botanical Magazine and other Journals in the process, encouraging field botany, instituting the system of students essays—a system which still prevails to-day—as well as developing the Botanic Garden, Brown was interpreting the morphology of the flower in such great groups as the Gramineae, the Asclepiads, the Orchids, the Rafflesiaceae and others, was showing the fundamental distinctions between the Dicotyledons and Monocotyledons and between Gymnosperms and Angiosperms, and thus was making important discoveries in the domain of morphology and systematic botany which did so much to overthrow the Linnaean System and to substitute for it a more natural system of classification. Moreover it was Robert Brown who, in 1831, showed the existence of the nucleus, a discovery which, together with the *Beiträge zur Phytogenesis* (1838) of Schleiden at Jena, laid the foundation of the cell theory and stimulated such workers in this field as Von Mohl and Naegeli who quite independently distinguished the cell wall from the cell contents, recognised the protoplasm (the word was first used by Von Mohl in 1846) and prepared the way for the physiological renaissance of Sachs and his school.

During Graham's regime the year 1836 is an important one in that it witnessed the foundation of the Botanical Society of Edinburgh. Only with one aspect of the Society do I propose to deal here. The Society developed its own Herbarium and Library through donations of Herbarium specimens and of books at almost every meeting. In 1839 the Society's Herbarium of about 150,000 specimens was amalgamated with the College Herbarium, the joint Herbarium was housed in the University, the Society was appointed perpetual Curator of it and the Professor of Botany "Honorary Curator for the time being." In 1851 the Herbarium was transferred to the Crown, was accommodated in the Royal Botanic Garden, accommodation which in 1859 was totally inadequate, and has been so for the last 100 years. In the Society's Library there were over 1,000 volumes by 1872 and it too was handed over to H.M. Office of Works with the stipulation that all future books of the Botanical Society would be likewise handed over. By thus transferring its Library to Government, the Society was "endeavouring to secure for Scotland what England already possesses in the valuable Government Library at Kew". In 1890, Government established a Curatorship of the Herbarium and Library carrying a salary of £130, rising to £200, a year. In this way were our present fine Herbarium and Library established and in this the Society can take great pride. It will be a wonderful day in the history of this establishment, and of this Society, when our great collections are housed in new quarters—a day, let us hope, we all may witness in the year 1962.

Just as Graham had come to Edinburgh from the Chair of Botany in Glasgow, so, in 1845, did his successor, John Hutton Balfour, who had occupied the Glasgow Chair since 1841 when Sir William Hooker had moved to Kew, there to develop the great Herbarium and Library, and the general layout of the Gardens, Glasshouses and Museums. It is of interest to know that Sir William's son, Joseph Dalton Hooker, was also a candidate for Edinburgh at this time. But Edinburgh passed him by, for the Edinburgh Chair, unlike the Glasgow one, had been the prerogative of the Scots and, indeed, continued to be so until 1958. So instead of becoming Keeper and Professor in Edinburgh he became Botanist to the Geological Survey and though he held this post only for 18 months a series of valuable papers on fossil botany in the *Memoirs* of the Survey was the result. He spent

the years 1847-51 in India and, as a consequence, published his *Rhododendrons of the Sikkim Himalaya* (1849-51) and the *Himalayan Journals* (1854). He became Assistant Director to his father at Kew in 1855, the year which saw the appearance of Vol. 1—and the only volume—of *Flora Indica* of Hooker and Thomson, and Director ten years later, the year following the publication of the first volume of the *Handbook of the New Zealand Flora.* He was Director of Kew from 1865-85, publishing during this period *The Flora of British India, The Students Flora,* in collaboration with Bentham *Genera Plantarum,* and, of course, founding *Index Kewensis.* Once again one cannot resist the speculation as to what might have been; what would have happened to botany in Edinburgh had Hooker's candidature—supported as it was by Humboldt and Robert Brown, among others—not been passed over in favour of that of Hutton Balfour? How much poorer would the world of botany have been if his candidature had been successful? Would Hooker have become the great traveller and geographer, geologist, morphologist, systematist, philosophical botanist and administrator that he proved himself to be?

The 34 years during which Hutton Balfour reigned in Edinburgh were remarkably significant ones in botanical history. The year 1859 was the momentous one which witnessed the publication of the *Origin of Species,* and the Darwinian viewpoint which did not regard the plant kingdom as a collection of more or less static units grouped together in immutable species, each one being created and arranged by the Creator in a master plan, but as a collection of changing things, interacting with their environment and constantly evolving new forms in response to environmental change, greatly influenced all branches of botanical thought. But apart from *The Origin* there were other important Darwinian works during this period; *Fertilization of Orchids* (1862), *Insectivorous Plants* (1875), *Cross and Self Fertilization in Plants* (1876), and *Movement in Plants* (1880). Darwin, an Edinburgh student by the way, is a fine example of what man may accomplish when he refuses to allow himself to be strangled by the rope, or even the red tape, of administration. Darwin apart, there was de Bary, engaged on his great work on comparative anatomy, his *Comparative Anatomy of Phanerogams and Ferns* of 1877, a work which paved the way for Van Tieghem's theory of stele on the basis of comparative morphology and

physiology. There was also de Bary deeply engrossed in the Fungi, defining the terms parasitism and saprophytism and working on his *Morphology and Biology of the Fungi* which appeared in 1884, the year Balfour died. There were the brothers Tulasne investigating the ontogeny of the Fungi and publishing their great work *Selecta Fungorum Carpelogia* between 1861-65; incidentally, Pasteur, too, was working during this period. There was Hofmeister demonstrating alternating generations in the plant kingdom, Farlow demonstrating apogamy in the Ferns in 1874 and Pringsheim apospory in the Mosses in 1877. In the field of plant physiology Sachs was concerning himself with the importance of root hairs and with the phenomenon of water movement in plants; Boussingault was conducting experiments in the assimilation of nitrogen; and two Englishmen, Lawes and Gilbert, in 1843 at Rothamsted, were conducting field experiments to show the effect of chemical fertilizers on the land and thus founding the experimental station which from this time forth was to solve many problems of soil science and plant nutrition. John Lindley, the first Professor of Botany at University College, London, and who, in his inaugural address in 1829 had frankly exposed the artificiality of the Linnaean system and did much to overthrow it, was spending half his life in building up the fortunes of the Horticultural Society, now the Royal Horticultural Society, proving himself the greatest scientific journalist of the period, striving to keep the science and practice of horticulture on good terms with each other, and in his *Theory and Practice of Horticulture* seeking to apply the physiological principles of the time (1840), somewhat crude though they may have been, to horticultural practice. In the field of plant geography, there were three workers who fully understood the significance of the Darwinian evolutionary concepts; August de Grisebach in Göttingen, who was defining types of physiognomy of vegetation in respect of climate and who published his *Die Vegetation der Erde* in 1872; Asa Gray in America, who was surveying the characteristics of the North American flora and defining its origin and affinities with other continental floras; and J. D. Hooker, Darwin's greatest and closest confidant, who was showing great interest in geographical distribution and elucidating problems of endemism and who, in the same year as *The Origin,* when working on his antarctic collections, had expressed his belief in the mutibility of species. And in the field of physiological plant geography—or

what we should now call ecology—there were Warming, Schimper, Schenck and others.

To return to Hutton Balfour. It had been his parents' wish that he be a Church of Scotland minister, and for some time Balfour was much under the influence of Professor Thomas Chalmers—the famous divine who was to play a leading rôle in the Disruption which founded the Free Church of Scotland—an influence from which Balfour never shook himself completely free. Perhaps rather naturally, therefore, the announcement of Darwin's Theory greatly shocked him. Still, though he could not accept the Theory, he did not publicly condemn it and evidently incorporated Darwin's work into his teaching. This is not surprising, for it is only what a good teacher would have done, and Hutton Balfour was nothing if not a teacher of the first order. Almost everything Balfour did was done on behalf of his students. For them he wrote text books almost encyclopædic in their coverage (his *Introduction to Palaeontological Botany* of 1872 being the first British text-book on palaeobotany). For several decades the Edinburgh Botany School had been noted for its emphasis on field botany; for his students Balfour elaborated the field work and practised what, at that time, undoubtedly was a fairly advanced ecological botany. And to the field work he added *laboratory* work, laboratory work which, let us not forget, had been practised, even though in somewhat elementary a fashion, by John Hope. At the time of his appointment in 1845 the Botany classroom in the Botanic Garden was far too small to accommodate his many students, and in any case was full of dry rot. By 1851 Balfour had succeeded in having a new and larger classroom built and had had the old one repaired and opened to the public as a Museum of Economic Botany. To illustrate his lectures, he introduced a system of demonstrations —as Hope had done—and it is on record that for an 8 a.m. lecture his students would appear at the Garden at 6 a.m. to arrange the material, living and dead, which he had amassed to illustrate his lecture. It is also on record that the walls of the lecture room always were tapestried with diagrams. His famous son, Isaac Bayley Balfour, later was to write "Never did teacher more sedulously absorb the new for presentation to his students".

For 25 years, both in the classroom and in the field, Balfour had the assistance of John Sadler who, in his day, had an almost unrivalled knowledge of the plants of Scotland, knowing mosses,

fungi, algae and lichens as well as he knew flowering plants. He discovered many new stations for plants and his name is perpetuated in several new species, possibly the most notable being the small Scottish Willow, *Salix sadleri*. With experience neither of practical gardening nor of horticulture he succeeded the great James McNab as Curator of the Garden in 1879, and was actively engaged in laying out the newly acquired Arboretum when he died in 1882.

James McNab, one of the founder members of the Botanical Society of Edinburgh and a one-time President, was Curator for 29 years. For some time McNab had acted as Clerk or Secretary to the Royal Caledonian Horticultural Society and in 1834, with the Perth Nurseryman, Robert Brown, had undertaken a botanical trip through the United States and Canada, had collected a large herbarium as well as living plants, and had recorded his journey in a series of papers in the *Edinburgh Philosophical Journal* for 1835 and in the *Transactions of the Botanical Society*. Shortly after his return, he had been appointed Curator of the Royal Caledonian Horticultural Society's Garden, which lay adjacent to the Botanic Garden, had remodelled the Garden, and with funds collected by his own personal efforts, had built a hall which is now the present Herbarium. When his father, William, died in 1849, James succeeded him as Curator of the Botanic Garden.

Thus for nearly thirty years the triumvirate of Balfour, Sadler and McNab held sway and the fortunes of the Garden greatly prospered. The acreage was more than trebled—this in large measure due to the incorporation into the Garden in 1865 of the Experimental Garden of the Royal Caledonian Horticultural Society and by the purchase of some 28 acres of Inverleith property from the Fettes Trust in 1877. In the Palm Stove which had beeen built in Graham's time the plants had flourished so well that some of them were now growing through the roof. As a consequence, in 1855 Balfour succeeded in persuading Parliament to vote £6,000 for the erection of a new Palm House—the Temperate Palm House of to-day—and three years later this beautiful building was completed at a cost of £6,500. The transference of some of the palms—they were all in tubs at that time—from the old Palm House to the new, must have been a considerable task for some of the tubs weighed as much as eight tons. However, McNab seems to have been equal to anything. Quite obviously

he was a brilliant horticulturist and one, moreover, who in some ways was ahead of his time as his writings on landscape gardening, the decoration and utilisation of waste places, railway embankments, town squares, etc., well show.

He died in 1878, and Balfour retired the following year. The finances of Balfour's various appointments had been curiously complicated. In 1862-63 the University Commission gave as salary £60 per annum compensation (for graduation fees) to the University Chair of Medicine and Botany, in addition to the £40 received from Leith Harbour Dues, making £100 in all. But they also took the £100 given by the Crown to the Keeper of the Garden and added it to the emoluments of the University Chair to make £200 salary and thus deprived the Keepership of any salary. In 1867 an Annual Grant of £120 was allowed to the Regius Professor and Keeper of the Garden, as house rent. But when ten years later Inverleith House and grounds were purchased by the Crown as an Arboretum, and when the Crown undertook to maintain a scientific educational institution, the Regius Professor and Keeper received Inverleith House as an offcial residence and the Annual Grant for house rent was stopped.

Balfour was succeeded by one of his old pupils, Alexander Dickson, who also came to Edinburgh by way of the Chair at Glasgow and the financial arrangements pertaining to Dickson were quite the reverse of those for Balfour which the University Commission had established in 1862-63. In Dickson's Crown Commission a salary of £160 was granted, that is to say the £100 which had been attached to the Regius Chair and Keepership in 1820, when Graham was appointed, and which the Universities Commission had taken away to add to the emoluments of the Curatorial (the patronage of the Town Council by this time had been transferred to the Board of Curators) Chair of Botany, was again granted; and the £60 which, as compensation for graduation fees was strictly attached to the University Chair of the Curators, was appropriated by Government to the Regius Chair and Keepership. So that had there been two different occupants of the Chairs, one, the Curators' Professor, would have had only £40, and the other, the Crown Professor, would have had a £160 a year salary.

A further interesting point about Dickson's appointment was that the link between Botany and Medicine was still further

weakened, for Medicine was not included in the title of the Chair. For all that, one who's primary training had been in medicine had to be appointed to the Chair. Dickson was a man of considerable private means with an estate in the country, and a man of considerable culture, being a pianist of some repute. Shortly after his appointment he was anxious to enlist the services of an assistant, and for this purpose interviewed, in Edinburgh, F. O. Bower who at this time was assisting Daniel Oliver at University College, London, and Huxley at the Normal School of Science at South Kensington. Bower was also a man of considerable culture, being a 'cellist of some repute, and should have appealed strongly to Dickson. However, nothing came of the interview and five years later Bower was translated to Glasgow to the Regius Chair of Botany which he was to hold for forty years, during this time extending the work of Hofmeister, Celakovsky and Pringsheim and attacking the problems of the evolutionary history of the Archegoniatae, and proving himself to be a botanist of world stature and indubitably the greatest figure in Scottish Botany.

Though Dickson took ample pains over his teaching, making great use of the blackboard—for he was also no mean artist—yet he had no great love for teaching. Much more interested was he working on the morphology and development of certain flowers, and of the pitchers of certain insectivorous plants including *Cephalotus,* the rare and interesting West Australian endemic which was in cultivation in Edinburgh in 1880 as it is to-day. In fact, Dickson's record of published research work exceeds by far that of any of his predecessors. Had *he* been allowed 34 years in office it is conceivable that he would have placed Edinburgh on the map as a botanical research centre. However, he died at the age of 51 in 1887, after only nine years in office and shortly after a new and enlarged lecture hall (the one used by the Botanical Society) had been built, to be succeeded by Isaac Bayley Balfour, son of John Hutton Balfour, and with whom the modern development of the establishment may be said to have begun. Like his father, Bayley Balfour held the reins in Edinburgh for 34 years. The two Hookers directed the fortunes of Kew for 54 years; the two Balfours directed those of Edinburgh for 68 years.

We have seen that during Huton Balfour's régime field botany had been the basic teaching in Edinburgh. Elsewhere in Britain

the approach was not so enlightened. Botanical teaching in large measure was concentrated on the medical students and floristic and systematic botany with a little spicing of morphology and pharmacy was the staple diet. The leaders of botany in Britain —Brown, Lindley and Hooker—were all primarily systematists and were all giants; but outside systematic botany the science in Britain virtually was dead. We have also seen on the other hand that in Europe many exciting new ideas and theories, anatomical, morphological, physiological, had been developed. That these ideas finally spread among British botanists was due to de Bary in Strassburg, to Sachs in Würzburg, and to the biologist T. H. Huxley in South Kensington, and one or two of Huxley's demonstrators.

At what is now the Royal College of Science, Huxley, the great champion of evolution, in the early 1870's, was giving a memorable course in elementary biology consisting of a daily preparatory lecture followed by personal observation by each student. In 1872 he was assisted in this by Thiselton-Dyer, who the following year was to be persuaded by Huxley to organise a similar course in botany to science teachers—a course which continued for several years; Thiselton-Dyer who was to assist in the translation of Sachs' *Text Book of Botany* (1875); who in 1875 was to become Assistant Director of Kew and Director in 1885; who during the next 20 years was to develop the Gardens, build the Temperate House, rebuild nearly all the glasshouses, extend the Herbarium, enlarge the Museums, do all possible to strengthen the relationship of Kew with the Colonies, and, not least important, equip the Jodrell Laboratory and encourage there Horace Brown's work on photosynthesis, Walter Gardener's work on protoplasm, Scott and Williamson's work on fossil plants, Bower's work on Ferns—and much else. In 1875, Thiselton-Dyer's demonstrator was Stanley Vines, then an undergraduate at Cambridge (where Babington was concerned only with the detailed systematics of the British and European Floras) but who later was to study with Sachs and de Bary, demonstrate in Cambridge many objects described in Sachs' Text Book and not seen in England before, pioneer work on the proteolytic enzymes, and become Professor of Botany at Oxford. In 1876 Dyer had an assistant additional to Vines—Marshall Ward—who was enthralled by the new laboratory teaching, "The Cause" as he called it, who had also studied with Sachs and de Bary, and who, after holding various posts, was

appointed to the Chair in Cambridge in 1895, there to develop a modern School of Botany. F. O. Bower, who with Ward had also been a student under Vines at Cambridge and who later was to work in Strassburg and Würzburg, also demonstrated at South Kensington.

One other fell under the spell of Huxley, not at South Kensington but in Edinburgh, in 1875, when Huxley was acting as deputy-Professor of Natural History whilst Wyvill Thomson was absent on the Challenger Expedition; one other fell under the spell of de Bary (the winter of 1877-78), and under the spell of Sachs (the winter of 1878-79)—Isaac Bayley Balfour who with Dyer, Vines, Ward and Bower, was to do so much to change the face of botany in Britain, to shift the emphasis from a study of the dead plant to the living plant, from the herbarium to the laboratory and garden, from external morphology to structure, function, development, and life history both of Phanerogam and Cryptogam. Bayley Balfour was to carry the New Botany, "The Cause", from Glasgow to Oxford, and thence to Edinburgh where, again let us not forget, its principles had been practised, even though in slight degree, first by John Hope and later by Balfour's father.

Balfour succeeded Dickson at the comparatively early age of 35 in 1888. At that time he was a much travelled man. In 1874 he had been the botanist with the Transit of Venus Expedition to Rodriguez and the botanical results of this trip he published in the *Philosophical Transactions* for 1879. In the winter of 1879-80 he had visited the Island of Socotra, studying the island from the geological and biological aspects, collecting over 200 endemic species of flowering plants, nearly all of them new, and almost 70 endemic lichens. His *Botany of Socotra* in the *Transactions of the Royal Society of Edinburgh*, 1888, is an impressive paper, as indeed are the memoirs on *Pandanus*, *Dracaena* and *Aloe* based on material collected during his visit; they are in part morphological, in part systematic and in part resolve some economic problems concerning certain well-known drugs. Even at this early stage in his career, he was the descriptive botanist his father always had refused to be. And even at this early stage he had the eye for a good horticultural plant, for he introduced to cultivation the free-flowering *Begonia socotrana* which has played so important a part in the creation of the races of winter-flowering Begonias which cultivators now have at their disposal.

At the age of 35 he was also a considerable administrator. He had succeeded Alexander Dickson in Glasgow when *he* moved to Edinburgh, had rebuilt the main range of planthouses in the Glasgow Botanic Garden, and had made the Kibble House into a Winter Garden; he had bartered away the only botany lecture room for two rooms suitable as a students laboratory and by so doing created a grievance which could only be set aright by the provision of new buildings, which, in fact, materialised in 1901. From Glasgow he had moved to Oxford in 1884, there to develop the Garden and reorganise the Herbarium and Library; there to found the *Annals of Botany* with the aid of a group of young enlightened botanists such as Vines; there, too, to induce the Clarendon Press to issue a series of English translations and revisions of translations of important foreign texts so necessary for the revival of botany in Britain.

Once in Edinburgh, Bayley Balfour strove tirelessly towards the reconstruction and development of the Garden and of the University Department of Botany in the Garden. The year after his appointment (1889) the entire Garden came wholly under the Crown, under the provision of the Act which regulates the Royal Parks (previously only part of the Garden had been under the Crown). In this same year the entire Garden was open to the public for the first time on Sundays—"a wanton desecration of the Sabbath" this act was called, even though part of the Garden had been open on Sundays for long enough. In 1890, strength to his arm was given by a Treasury Commission which recommended various changes which Balfour gradually proceeded to put into effect as the funds became available. In this he was assisted by his Curators, or Head Gardeners, as they have been variously called; first Robert Lindsay, an authority on the genus *Nepenthes*—which group of plants was the subject of his Presidential Address to the Botanical Society in 1889—and on the shrubby Veronicas, the pink flowered *V.* × *lindsayi* or *Hebe* × *lindsayi* (*amplexicaulis* × *pimeleoides*) being a hybrid of his raising; then Adam Richardson who came to the Garden in 1880, who had been Assistant to John Sadler and who resigned in 1902 to take up landscape gardening and advisory work; and finally Robert Harrow, appointed Head Gardener in 1902, Curator in 1924, and then retiring in 1931 to move to Wisley. The great wall, which separated the old Botanic Garden of 1820 from the Experimental Garden which had been taken over in 1865, was

removed, so that the re-arrangement of the entire Garden and the development of the Arboretum could proceed. Trees 30-40 feet high were successfully removed on specially constructed waggons to more suitable sites. The new Rock Garden took on its present form. Gradually, all the glasshouses except the two Palm Houses were removed and new houses, potting sheds, and propagation pits were erected. In Hutton Balfour's time there had been no fewer than 22 different furnaces and 18 or 19 stoke-holes in different places. All these were incorporated into one central stoke hole near the back of the Palm House, with four large boilers and room for a fifth. The old Palm Stove formerly was heated by means of a number of small square chambers on the outside of the walls. In 1892-3 these were cleared away, the lower walls opened up and encircling the house on all sides except that adjacent to the Temperate Palm House was erected an iron and glass annexe, thus giving about 200 ft. of staging. The total cost of reconstructing the Palm Stove and of the new heating arrangements was about £3,000. In these Palm Houses the tubs which held the specimen plants were abolished and everything was planted in the open ground. By 1898 a new glasshouse range was erected with a frontage of 340 ft.; a Centre House with Rhododendrons and Camellias, Myrtles and Acacias (this is the house which is now in such poor repair) and four Conservatories —for stove plants, Orchids, economic plants and succulents. In 1908 a new fernery was opened for tropical ferns (on the site where William McNab had grown his remarkable Cape Heaths) as well as two houses, one for temperate Ferns and one for Heaths. By 1915 the present Rhododendron House and two Rock Houses had been built. And just before the 1914 War the development of the frame yard began and the task was barely completed in 1921.

In the meantime, since Hutton Balfour's latter days, the horizon of the science of botany had widened enormously. Volume 1 of Engler and Prantl's 20-volume work, *Die Natürlichen Pflanzenfamilien*, had appeared in 1887, the year Dickson died. In morphology Nägeli had coined the word meristem, the concept of the meristem was being elaborated and the importance of developmental studies being emphasised; Hanstein had formulated the Histogen Theory of the cell apex; Hofmeister's work on Alternation of Generations was being elaborated by Celakovsky, Bower and Strassburger. Goebel's *Organographie* had emphasised

that morphology should no longer be allowed to remain a thing apart from physiology, and Haberlandt (*Physiologische Pflanzenanatomie*, 1884) that structure was related to environment. In plant physiology the problems of the ascent of sap in stems were being illuminated by Dixon and Joly; Brown and Escombe were illuminating problems of respiration and assimilation by their discovery of the rapid diffusion of gases through small apertures; Willstätter and his colleagues were elucidating problems in the chemistry of chlorophyll; Winogradsky and others the main processes in nitrification. And possibly most important of all Strassburger was creating a school of cytological research at Bonn and was laying the foundation of our modern cytology and genetics, demonstrating, among much else, reduction division in the germ cells of Angiosperms and in Mosses and Ferns; Tangl had demonstrated continuity of protoplasm from cell to cell and Pfeffer and de Vries were appreciating the true nature and importance of the vacuole.

Thus, when Bayley Balfour came to Edinburgh in 1888, the times were wonderfully stimulating. The times were also impossibly exacting, for now the whole wide field of botany was covered by the Professor, working single-handed and without teaching assistance. However, the following year the New Ordinances under the Universities (Scotland) Act were to change all this. Degrees in science were established, advanced courses of instruction had to be given and, consequently, greater accommodation and staff for teaching and research had to be found. Thus, gradually, from this time onwards, the present Laboratory building took on its present framework, the last addition being made in 1921 when the big laboratory was completed and wherein a large demonstration of the newly discovered Rhynie Chert fossils was staged at the meeting of the British Association.

As a result of the new University Ordinances, Bower in Glasgow assembled a group of investigators—Bower, Lang, Gwynne-Vaughan, and the palaeontologist Kidston—who not only renewed continuity with the Hookerian tradition by making a special study of the living Archegoniatae, but extended their study to the cognate fossils. The beautiful memoirs resulting from this teamwork are known to all. In Edinburgh, Balfour made Government appointments to the Herbarium, Library, Laboratory,

Studio and Museum and to augment his University Staff created Lectureships and Assistantships in Botany, Forest Botany, Plant Physiology and Mycology. I think it is true to say that more emphasis was placed on teaching than on research and certainly it is true that during his regime Edinburgh became the chief centre in Britain for the teaching of systematic method as applied to flowering plants. As Bower, his greatest, and I believe greater, contemporary has said: "It was a real modern organography that he taught, grafted upon the old systematic methods, and with a knowledge such as few ecologists could aspire to". Neither was teaching confined to University Students, for as early as 1892, through Balfour's initiative, a scheme was inaugurated for the training of Student Gardeners and Foresters in the sciences underlying the practice of horticulture and forestry.

A remarkable man, holding a very meagre post in the Herbarium in 1904, decided the form Balfour's research work, and ultimately in large measure the work of the Garden, should take. This was George Forrest who in 1904 made the first of his seven plant collecting expeditions to Western China. In 1900 Balfour undoubtedly was aware of the richness of the flora of the provinces of Western China. The collections of Augustine Henry from the Western areas, and of the French Missionaries David, Soulié and Delavay from Szechuan and Yunnan, offered abundant evidence of this. But most of the evidence was dried material in various Herbaria. Forrest, on the other hand, from 1904 onwards, was not only sending to Edinburgh some of the most beautiful herbarium material ever collected but pounds of seeds as well. Balfour realised that such material would not only enrich the collection of living material in the Botanic Garden, but that if enough of it could be procured it would greatly change the face of gardening in Britain; *Aucuba, Ligustrum,* Holly and Yew would give place to *Rhododendron, Primula, Gentiana* and *Meconopsis.* Thus for the rest of his life he devoted himself to two objects; to the systematisation of this new Chinese material—making himself one of the foremost authorities on the vegetation of Western China, and particularly on the genera *Primula* and *Rhododendron,* and eventually the chief exponent of the phytogeographical relationships subsisting between the flora of the escarpments of the Tibetan tableland generally and that of High Asia on the one hand, and those of Central China and Northern India on the other

hand; and to solving the problems of the successful cultivation in Britain of this newly introduced material. In the latter project great assistance was given to him not only by his Head Gardener, Harrow, but also by another of his gardening staff, Laurence Baxter Stewart, who was associated with the Garden for over 30 years and who made a special study of propagation. And in the former project the one who worked closest with him was the one who was made his Deputy in 1911 and who succeeded him eleven years later to the dual post of Regius Keeper of the Garden and Regius Professor of Botany in the University of Edinburgh—William Wright Smith.

Although I have said nothing of the close relationship between the Garden and the University Department of Botany with the Gardens and the Botany Departments in the Universities of Aberdeen and St. Andrews, it is appropriate at this point to close this story for I believe that the developments since 1922 in the Edinburgh Royal Botanic Garden, as well as the developments in the Edinburgh University Department of Botany, are too close upon us to permit of a fair evaluation. Nor, at this moment, is it easy to evaluate the progress of our science during the last three or four decades. It should be remembered, however, that in morphology the Histogen Theory of Hanstein has been generally displaced by the Tunica-Corpus Theory of Schmidt; that in *Size and Form* (1930) Bower has most masterfully discussed the morphological and physiological relations of the evolving plant kingdom; that as a result of Goebel's doctrine that sporangia are organs *sui-generis* as much as shoots and roots, there have been many discussions as to the nature of the flower—Bower, Arber, Eames, Saunders, Grégoire, Troll, McLean-Thompson, Hamshaw-Thomas (from a palaeontological viewpoint); that the discovery of virus diseases has opened a new chapter in plant pathology; and that the sciences of comparative or systematic embryology, cytogenetics and cytotaxonomy have been established.

A Pollen Diagram from a Blanket Bog in the Campsie Fells.

H. Ronald Eydt
(National Research Council of Canada Scholar),
University of Glasgow*.

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Introduction.

Some Scottish peat bogs were examined by Erdtman (1924) in the early twenties, but from then until comparatively recently pollen analysis has not been actively used in Scotland. Within recent years, papers by Blackburn (1946), Durno (1956, 1957), Fraser and Godwin (1957), Knox (1954) and Mitchell (1951) have extended our knowledge of late-glacial and post-glacial forest history. These works have not accumulated enough evidence as yet to form a complete picture of plant succession in post-glacial Scotland. Thus, in Scottish papers, the results have been compared with those of other workers, principally with those of Godwin and his associates. It was decided to examine a bog for pollen with the intention of narrowing the gap in our knowledge, and it is hoped that the history of the development of the Scottish flora soon will be as well recorded as is the English.

Material and Method.

The bog which was examined is located on the Campsie Fells in a glacial overflow channel between the Forth and Clyde Valleys between Lennoxtown and Fintry. The upper slopes of these hills are covered with a blanket bog. The depth of the peat varies, but random borings suggested that the average depth is about six feet. Samples of peat were collected from the face of a peat cutting at an altitude of 1,100 feet (O.D.). At this location, about three hundred yards east of the Roadman's Cottage on the Crow road, which runs through the valley formed by the overflow channel across the hills, the peat was 170 cm. (68 inches) deep.

A Hiller Borer was used to determine the depth of the peat in the area, but it was not used to collect the samples because these were being used not only for this pollen study, but also for a study of peat structure. The samples were obtained from a complete

*Present address: Department of Biology, Waterloo University, Ontario.

vertical column, three by three inches, and were stored in appropriate boxes. From this column and from the face of the peat cutting, the layering of the peat was seen to be as follows:

1-11 inches	*Sphagnum* peat.
12-20 inches	Small woody fragments in *Sphagnum* peat.
21-26 inches	Highly humified peat.
27-60 inches	Woody fragments in humified peat.
61-68 inches	Highly humified peat—no woody fragments.
Below 68 inches	Boulder clay.

At intervals of five centimetres along the column, one gram of peat was removed and treated with KOH then submitted to acid

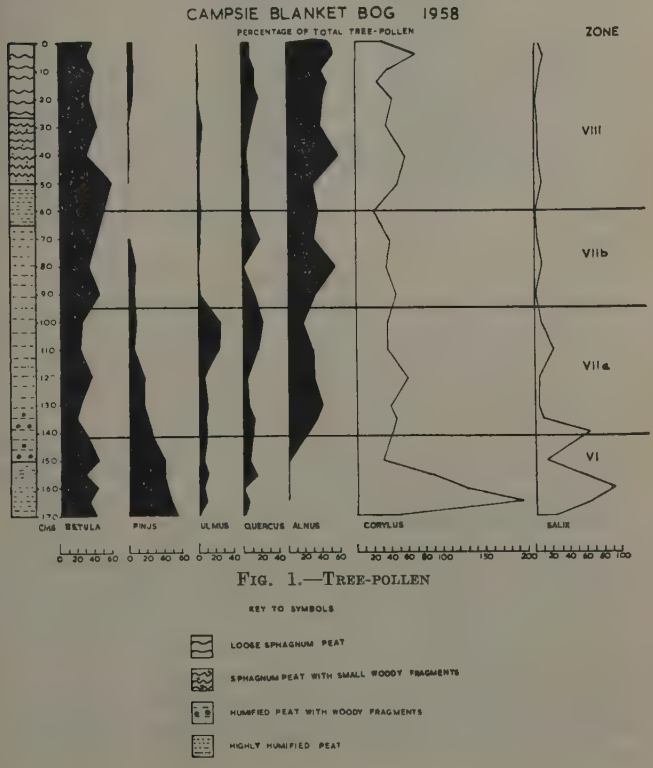


FIG. 1.—TREE-POLLEN

hydrolysis as described by Godwin (1956). The pollen grains thus isolated were then mounted and counted. Most of the countings were taken at ten centimetre intervals, but some were taken at intervals of five centimetres where zone changes were not clear. All pollen grains encountered in each sample were counted until 150 tree pollen grains (*Corylus* and *Salix* not included) were recorded. Then the results for each species, or group of species, were expressed as percentages of the total tree-pollen.

RESULTS.

The pollen diagram for the tree pollen, including *Corylus* and *Salix,* is given in Fig. 1. It will be obvious that *Fagus, Tilia* and *Fraxinus* are not mentioned because pollen of these genera did not occur in any of the samples. One of the most notable features of this diagram is the abrupt rise and subsequent fall of the hazel pollen. Birch pollen is almost always at a high frequency, and after alder pollen appears, these two are the dominant tree pollen grains. Pine is the dominant tree pollen in the lower part of the deposit, but it decreases until at a depth of 60 cm. no pine pollen is recorded at all, although it does re-appear in small percentages above.

There are small numbers of oak and elm pollen grains in the deepest sample. These grains increase in frequency and then fall, but do not disappear completely from the pollen record. The frequency of elm pollen grains after a decline at a depth of 90 cm. is never high again, whereas that of the oak rises until it is third in importance at the surface, next to birch and alder.

Among the non-tree pollen (Fig. 2) the high percentages of ericoid pollen grains at the top of the graph are striking. They appear first at a depth of 80 cm. in small amounts, but above 40 cm. they rise sharply and stay at a high level.

The percentages of both the Cyperaceae and the Gramineae pollen grains fluctuate greatly, but are most abundant at the top and the bottom of the peat. Fern spores are continually present, but never in great abundance. The spores of Sphagna were irregular in occurrence.

Wood from the 55-60 inch depth was of sufficient size to be identified, on the basis of anatomical evidence, as *Alnus* (Metcalfe and Chalk, 1950).

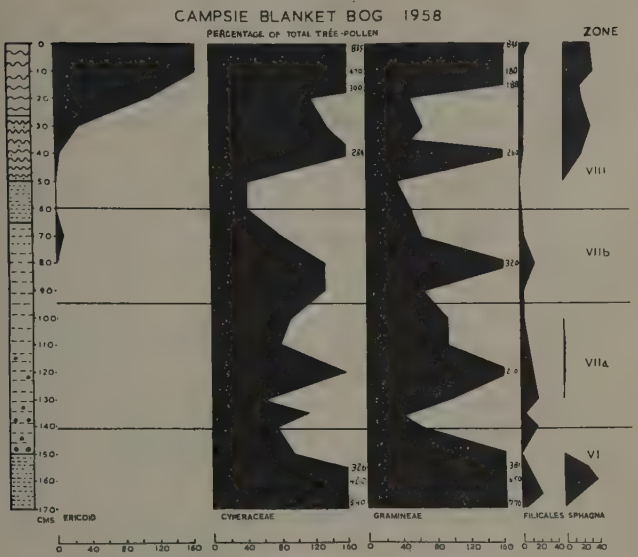
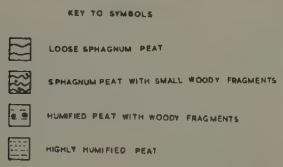


FIG. 2.—NON-ARBOREAL POLLEN


KEY TO SYMBOLS
LOOSE SPHAGNUM PEAT
SPHAGNUM PEAT WITH SMALL WOODY FRAGMENTS
HUMIFIED PEAT WITH WOODY FRAGMENTS
HIGHLY HUMIFIED PEAT

DISCUSSION.

The absence of *Fagus, Tilia* and *Fraxinus* was not entirely unexpected because their occurrence in Scotland has been shown not to be frequent in the post-glacial period, although they have been found on occasion in the Scottish pollen record.

The sudden rise in hazel at depth 165 cm. is taken as the indicator for Zone VI, as proposed by Godwin (1940). Because the rise in hazel is only 5 cm. from the bottom of the peat, it seems most probable that the blanket bog started to deposit peat during Zone VI. This supports Fraser (1943), who considers that the majority of Scottish peats began in the Boreal (Zones V

and VI). Hazel here rises to only two hundred per cent., which is a far lower percentage than can be found for hazel in Ireland, but it is comparable to other Scottish and English results. Associated with the sudden rise in hazel, and subsequent fall at depth 160 cm., oak and elm rise, and alder makes its appearance. As they rise, birch and pine fall slightly.

The rise of alder and the fall of pine and birch is associated with a fall in hazel, and is taken as the division point between Zone VI and Zone VIIa. Alder, after its rise, stays at a relatively high frequency. Oak and elm both have their maxima in this period.

The fall of elm at a depth of 95 cm. is taken as the end of Zone VIIa. Oak declines more slowly than elm, and whereas oak recovers some of its value late in this new zone (Zone VIIb), elm never does. Birch recovers some of its value, while pine continually decreases until it is absent at a depth of 60 cm. This absence is taken as an indication of a change. It is assumed to be the beginning of a new zone (Zone VIII). In the peat column, it was seen that at level 50-65 cm. there was a layer of highly humified peat. This can be correlated approximately with the same horizon that Blackburn found in Barra (1946). This layer of peat is probably a "Grenzhorizonte", possibly RY III. Blackburn used this layer of peat as the indication of a change in climate, hence the change from Zone VIIb to Zone VIII. In this blanket bog, the "Grenzhorizonte", together with the absence of pine pollen grains, is used as evidence of a change. Between this layer of peat and the surface of the bog, there is a tremendous rise in non-arboreal pollen grains.

From Fig. 2 it can be seen that between depths 150 and 170 cm. and also between 0 and 50 cm., pollen of the Cyperaceae and Gramineae and the spores of Sphagnaceae reach high values numerically, which indicates a moorland surface vegetation rather than a forest. It can also be seen from the abundance of non-arboreal pollen throughout the pollen diagram that this blanket bog was undoubtedly moorland during the greatest part of its history. The woody fragments identified as *Alnus* at depth 145 cm. suggest, however, that alder trees at one time grew on this bog. All the fragments examined were *Alnus* wood, and it was assumed that most other arboreal pollen grains recorded in this work were blown in from a distance.

In Zone VIII, the association of *Sphagnum* spores, the appearance of ericoid pollen, and the high value of the Cyperaceae and Gramineae pollen suggests that the present surface vegetation is much as it was shortly after this zone started. The surface of the bog is being grazed by sheep, and drainage ditches have been dug recently. These factors may explain the very high frequency of Gramineae and Cyperaceae pollen grains at a depth of a few millimetres.

The depth of the Campsie blanket bog is only 170 cm. (68 inches) which is comparatively thin considering the length of time peat has been developing. It is known, however, that blanket bogs generally develop more slowly than raised bogs, which may explain the relative thinness (Fraser, 1943).

Oak pollen is more abundant in this diagram than is usually found in Scotland, though it is not as abundant as from peats in southern England of the same age. This perhaps may be explained by the milder climate found in the west of Scotland. Thus it may be said that while the frequency of oak pollen grains varies from south to north, it also varies from east to west.

SUMMARY.

A pollen diagram describes the forest history as recorded by a blanket bog 170 cm. in depth. Peat deposition is believed to have started in the Boreal period.

The frequency of non-arboreal pollen grains and spores was always high in relation to that of the arboreal pollen grains, indicating a moorland surface vegetation throughout most of the life of the bog; it is assumed that most arboreal pollen grains were blown in.

From comparison with British works on pollen analysis, it is noted that the frequency of birch pollen increases as one goes north in Britain, whereas oak decreases. However, this bog from the west coast of Scotland shows a higher value for oak than is usual.

The system of zonation proposed by Godwin (1940) is applicable in this work, and peat stratigraphy also is used, especially the "Grenzhorizonte" at depth 50-65 cm. which is comparable to RYIII of the Continent.

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Predacious Fungi of the Edinburgh District

By D. W. R. Mackenzie
(Department of Microbiology, Queen's University, Belfast).

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Introduction.

Predacious fungi are those which capture and consume microscopic animals, and although this type of nutrition was first recorded by Zopf in 1888 most of the work on this group has been carried out within the last twenty-five years. "Predatory" fungi have been the subject of several reviews (Drechsler, 1941a; Duddington, 1950a, 1955, 1956) which give a complete outline of morphological, taxonomical, and biological aspects. These reviews also provide access to the literature on the subject. Accordingly, in the present paper, only a brief outline of the group will be given, with mention of the types concerned.

Predacious fungi can be placed conveniently into three categories, viz., (1) Zoopagales; (2) Hyphomycetes; (3) other groups. The Zoopagales are members of the Phycomycetes and include the genera *Zoopage, Cystopage, Stylopage, Acaulopage, Cochlonema, Endocochlus,* and *Bdellospora.* Special modifications for the capture of their prey are usually absent, and individuals are characterised by their small size. Amoebae are the common host animals, although one or two of the more robust members are capable of capturing and consuming nematode worms. All the species within this group appear to be obligatory predators since every attempt to grow them in pure culture has been unsuccessful.

The predacious series of Hyphomycetes can be subdivided into true predators, with a spreading vegetative mycelium which gives rise to special modifications associated with the trapping of host animals, and endozoic forms where the vegetative mycelium exists only within the body of the host. In the latter case, external mycelium is represented solely by the sporogenous hyphae and is produced only after the establishment of the endozoic phase. Members of the true predacious Hyphomycetes are confined to the genera *Arthrobotrys, Dactylaria, Dactylella,* and *Trichothecium,* and show the greatest morphological response to their mode of existence. Highly specialised and highly

efficient trapping mechanisms are present in all the species within this group, and can be referred to retiary, constricting ring, or adhesive types. In the first type, repeated production of short recurved branches in different planes forms a three-dimensional network. Capture of the host animal is effected partly by entanglement in the loops and partly by the production of an adhesive substance. In constricting ring traps, a short lateral branch from the parent hypha recurves and unites with itself to form a closed ring at the end of a short stalk. The ring invariably has three component cells. When a host animal

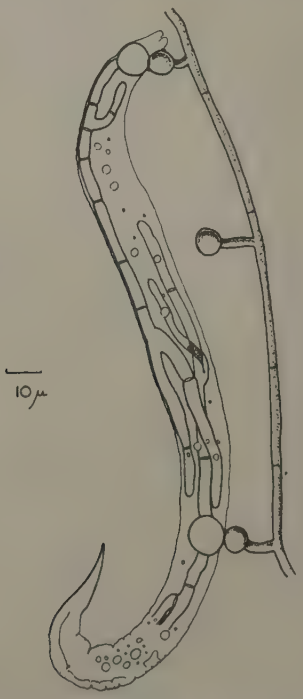

FIG. 1.

Nematode trapped and partially digested by adhesive knobs of *Dactylella asthenopaga*. Two infection bulbs which are produced following penetration of the cuticle of the nematode can be seen, from which branched, septate, trophic hyphae have been produced.

attempts to pass through the aperture, the three cells swell up with great rapidity and prevent any possibility of escape. Invasion of the trapped host and assimilation of its contents by trophic hyphae then occurs. In some members of the predacious Hyphomycetes capture of the prey is achieved by adhesive knobs. These consist of short branches arising from the parent hypha, and ending in a more or less globular head which is extremely viscous. The host animal is trapped by simple adhesion, whereupon branches penetrate the host and establish the trophic phase within the animal (Fig. 1). In one or two species, the knobs may be sessile on the parent hyphae.

Endozoic Hyphomycetes, in contrast to the true predacious fungi, lack these adaptations and modification of structure is confined to spore shape or nature, such peculiarities being associated with reinfection of new hosts: thus, several species of *Harposporium* have adhesive spores which become firmly attached to the cuticle of the host animal, facilitating the establishment of the endozoic phase.

The third group of predacious fungi includes certain representatives of the Lagenidiales in the Phycomycetes, and one or two species of uncertain taxonomic affinities. Included in this group are such species as *Protascus subuliformis, Myzocytium vermicolum, Gonimochaete horridula, Haptoglossa heterospora, Meristacrum asterospermum,* and *Sommerstorffia spinosa.*

The fungi recorded in this paper are those which appeared during an attempt to isolate species of *Arthrobotrys, Dactylaria, Dactylella,* and *Trichothecium.* During the search for these species other types were seen, and the purpose of the present publication is to record the species encountered in the course of the investigation: in this respect it can be regarded as a preliminary survey of the predacious fungi occurring in the Edinburgh district.

ISOLATION AND IDENTIFICATION.

Pure cultures of *Arthrobotrys, Dactylaria, Dactylella,* and *Trichothecium* were obtained by picking off conidia from the aerial conidiophores by means of a sterile inoculating needle and transferring them to the surface of a maize-meal agar plate. Spore measurements are of critical importance in the identification of species and whenever possible these were made from nematode-infested cultures. This method was adopted since it is well known that conidia from pure culture are often much smaller than those

produced in nematode-infested plates: thus it was noted that 100 spore measurements of *Arthrobotrys oligospora* in nematode-infested cultures yielded an average size of 28μ × 15·2μ, whilst a similar number of measurements of the conidia produced in pure culture averaged 24·7μ × 14μ. In other instances the disparity was even greater. In a number of cases the quantity of spores observed was too small to permit accurate assessments to be made and measurements were then made from conidia produced in pure culture. It was found that these measurements fell within the range of spore dimensions recorded for each species, and they were therefore considered to be diagnostic in the identification of the isolate concerned. When some doubt existed, the conidia were re-seeded on the fresh surface of some maize-meal agar which had been added to a culture already containing nematodes. Many aerial conidiophores were rapidly produced on the agar surface and fresh measurements were then made. This method had an additional advantage in confirming the type of predacious apparatus produced by the fungus, since the fresh surface of the agar was quickly colonised by nematodes, whose presence appears to be essential in some cases for the production of trapping mechanisms. Productions of predacious traps in pure culture is not common, and where the fungus was growing on an opaque portion of the inoculum it was sometimes impossible to determine whether retiaries, knobs or constricting rings were produced. By means of the method just described both the predacious nature and the morphological characteristics of the isolate were readily determined. In general, however, when conidial stages were seen on nematode-infested cultures it was possible to confirm their association with specific trapping mechanisms.

Apart from conidial size and the type of predacious apparatus, it was also necessary to observe the method of conidial production. In *Dactylaria*, for example, the conidia are borne plurally, whilst the conidiophores of *Dactylella* usually bear a single apical conidium. This distinction does not appear to be fundamental, for most of the predacious Dactylellas when growing in nematode-infested cultures produce two or even three conidia on a single conidiophore, presenting a loosely racemose type of conidial arrangement more reminiscent of *Dactylaria* than *Dactylella*. In *Arthrobotrys*, although originally described (Zopf, 1888) as having the conidia produced in clusters along the length of the conidio-

phore (Fig. 2a), some species are characterised by the production of branched conidiophores, the conidial heads being produced at the ends of these branches (Fig. 2b). The latter type of conidiophore was originally described by Drechsler (1937) in *A. cladodes*, and he does not consider that the character justifies separation from the genus. Duddington (1951) reported a similar type of branching in his *A. robusta*.

In nematode-infested cultures the conidiophores of *Arthrobotrys* often bear a single apical cluster of conidia. Such monocephalous conidiophores do not indicate if the production of

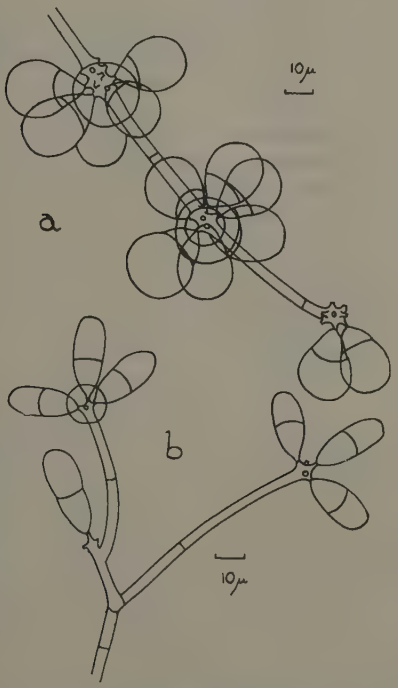

Fig. 2.

Method of production of conidia in *Arthrobotrys*:
(a) Uniaxial growth of the conidiophore showing whorls of conidia. *A. oligospora*.
(b) Branched conidiophore of *A. robusta*.

succeeding spore clusters is brought about by axial elongation or by axial branching of the conidiophores: this can be determined only by growth in pure culture. On maize-meal agar the growth of the conidiophores is very luxuriant and the distinction between the two types of conidial production can be readily seen.

Many of the apparently obligate predators cannot be cultured and all measurements and drawings were then made *in situ*; alternatively, small discs were cut from the medium and mounted for observation directly on a microscopic slide as recommended by Duddington and Dixon (1952).

SPECIES RECORDED

Table 1 lists the predacious fungi observed, with the total number of records for each species. In addition, the number of records for each of ten different habitats is indicated. Sources of material were as follows: —

I—Leaf mould
II—Decaying wood
III—Decaying vegetation
IV—Moss plants
V—Bark
VI—Decaying roots
VII—Natural soil
VIII—Cultivated soil
IX—Compost
X—Fungal fructifications

TABLE 1.

DISTRIBUTION OF SPECIES OF PREDACIOUS FUNGI FROM DIFFERENT SOURCES

	SOURCE										
	I	II	III	IV	V	VI	VII	VIII	IX	X	Total
ACAULOPAGE sp.	—	—	—	—	—	—	—	—	2	—	2
ACAULOPAGE TETRACEROS	2	—	—	—	—	—	—	—	—	—	2
ARTHROBOTRYS sp.	3	1	—	1	2	—	—	1	1	1	10
A. CLADODES V.MACROIDES	3	—	1	1	1	—	—	—	—	—	6
A. CONOIDES	1	—	—	—	—	—	—	—	—	—	1
A. OLIGOSPORA	5	—	4	—	—	—	—	2	—	—	11
A. ROBUSTA	12	—	2	1	4	—	—	—	—	3	22
A. SUPERBA	1	—	—	—	—	—	—	—	—	—	1
ACROSTALAGMUS sp.	1	—	—	—	—	—	—	—	—	—	1
A. GONIOIDES	—	—	—	—	2	—	—	—	—	—	2
A. OBOVATUS	1	—	—	—	1	—	—	—	—	—	2
COCHLONEMA sp.	1	—	—	2	—	2	—	—	—	—	5
C. VERRUCOSUM	—	—	1	—	—	—	—	—	—	—	1
CYSTOPAGE sp.	1	—	—	—	—	—	—	—	—	—	1
DACTYLARIA sp.	1	—	2	—	—	1	—	—	—	—	4
D. BROCHOPAGA	1	—	—	—	—	—	—	—	—	—	1

	SOURCE										
	I	II	III	IV	V	VI	VII	VIII	IX	X	Total
D. GRACILIS	6	1	—	—	—	—	—	—	—	—	7
D. THAUMASIA	—	—	—	2	—	—	—	—	—	—	2
DACTYLELLA sp.	8	1	—	—	1	—	—	1	—	—	11
D. ASTHENOPAGA	—	—	—	—	—	—	1	—	—	—	1
D. BEMBICOIDES	2	—	—	—	—	—	—	—	—	—	2
D. CIONOPAGA	8	—	—	—	—	—	—	—	—	2	10
D. ELLIPSOSPORA	3	2	—	—	—	—	—	—	—	—	5
D. PHYMATOPAGA	1	—	—	—	—	—	—	—	—	—	1
HARPOSPORIUM ANGUILLULAE	5	1	—	—	—	—	—	—	—	1	7
STYLOPAGE sp.	1	—	—	—	—	—	—	—	—	—	1
S. RHYNCHOSPORA	1	—	—	—	2	—	—	—	—	—	3
TRICHOTHECIUM CYSTOSPORIUM	—	—	2	1	—	—	—	—	—	—	3
Unidentified retiary traps	1	—	1	1	—	—	1	—	—	—	4
Unidentified endozoic hyphae	1	—	—	1	1	—	—	—	—	—	3
Totals	70	6	13	10	14	3	2	4	3	7	132

A more detailed analysis of the sources examined and the number of predacious fungi isolated from each is given in Table 2.

TABLE 2.

DISTRIBUTION OF PREDACIOUS FUNGI AMONG DIFFERENT SOURCES

Source	No. of samples	No. of predacious fungi recorded
Leaf mould	76	70
Bark	11	14
Mosses	19	10
Decaying plant parts	28	7
Fungal fructifications	9	7
Vegetation with adherent particles of soil	16	5
Rotting wood	7	6
Cultivated soil	5	4
Uncultivated soil	4	2
Grass compost	4	3
Dead twigs	2	—
Rabbit dung	3	—
Mouse dung	3	—
Horse dung	5	—
Decayed seedlings	2	—
Healthy stem material	4	4
Pond scum	2	—
Freshly cut grass	3	—
Lichen	2	—
Totals	205	132

Table 3 indicates the spore dimensions of the isolates obtained in the course of the survey. These are compared with the dimensions reported by previous workers. All measurements are given in microns.

TABLE 3. SPORE DIMENSIONS OF 19 SPECIES OF PREDACIOUS FUNGI

*(a) dimensions previously reported (b) dimensions recorded by author

Species		Dimensions μ Length range	Length average	Breadth range	Breadth average	Author
ACAULOPAGE TETRACEROS	(a)*	16-24	20	7-10	8	Drechsler (1935b)
	(b)	18-25	22	7-10	8	
ARTHROBOTRYS CLADODES	(a)	13-26	17·6	5-8·2	6·4	Drechsler (1944)
var. MACROIDES	(b)	14-25	19·6	6·5-8	7·2	
ARTHROBOTRYS CONOIDES	(a)	19-42	30	8-15	12	Drechsler (1937)
	(b)	17-30	23	8-13	11	
ARTHROBOTRYS OLIGOSPORA	(a)	22-32	26·6	12-20	15·8	Drechsler (1937)
	(b)	20-37		12·5-19	15·2	
ARTHROBOTRYS ROBUSTA	(a)	18-27	27	8-12		Duddington (1951 c)
	(b)	15-28	23·6	8-12	9	
ARTHROBOTRYS SUPERBA	(a)	12-23	16·8	6·5-9·5	7·8	Drechsler (1937)
	(b)	15-19	17	7-9	8	
ACROSTALAGMUS GONIOIDES	(a)	1·3-2·1	2·5	1·3-2·1		Drechsler (1942)
	(b)	2·3-2·8	3	1·4-1·6	1·5	
ACROSTALAGMUS OBOVATUS	(a)		2·5		2	Drechsler (1941b)
	(b)	2·4-2·6	3	1·5-1·9	1·8	
COCHLONEMA VERRUCOSUM	(a)	6-9	2·5	1·4-2		Drechsler (1935a)
	(b)	4-7	6·2	1·5-2	1·8	
DACTYLARIA BROCHOPAGA	(a)	26-46		5-9		Drechsler (1937)
	(b)	38-45	42	5·8-7·5	6·7	
DACTYLARIA GRACILIS	(a)	46-66		7-11		Duddington (1951a)
	(b)	45-58	51	7-11	9	
DACTYLARIA THAUMASIA	(a)	27-49	37	15-23	19·2	Drechsler (1937)
	(b)	33-44	36	12·5-20	17·3	
DACTYLELLA ASTHENOPAGA	(a)	26-36	31·5	6·5-9·5	8·2	Drechsler (1937)
	(b)	28-40	34	7·5-11	9·1	
DACTYLELLA BEMBICOIDES	(a)	34-48	42	16-23	20	Drechsler (1937)
	(b)	41-50	45	15·4-21	18·1	
DACTYLELLA CIONOPAGA	(a)	40-53		15-21		Duddington (1950b)
	(a)	35-60		13-21		Drechsler (1950)
	(b)	38-50	46	16-21	18	
DACTYLELLA ELLIPSOSPORA	(a)	24-65		7·5-19		Drechsler (1937)
	(a)	37-50		11-15		Duddington (1950b)
	(b)	33-56	46	10-14	11·6	
HARPOSPORIUM ANGUILLULAE	(a)	5-14		1·5-2·5		Karling (1938)
	(b)	8-14	11·2	1·5-2·4	1·8	

The ecology of predacious fungi has been considered by Duddington (1951b) and the results obtained in the present work generally confirm his observations, although certain quantitative differences are nevertheless apparent. Living Bryophytes, for instance, did not yield the rich predatory mycoflora encountered by Duddington, but the numbers of samples from this source in the present work are too small to be considered representative.

Table 4 indicates the quantitative differences between the results obtained by Duddington and those of the present writer for certain sources, where the numbers of collections may be considered comparable. It must be realised that quantitative differences of this kind may well be the outcome of differences in sampling techniques, and that furthermore the separation of sources into various types is often extremely arbitrary: thus leaf mould may contain decayed plant remains, fragments of bark, rotting wood, soil, or various combinations of these materials. It is, therefore, suggested that as these sources are somewhat artificially distinguished from one another, it may be inadmissible to equate numbers with sources or to ascribe differences in numbers to differences in environment. Nevertheless, from the evidence which has already been made available, it seems likely that quantitative differences are real rather than apparent, although confirmation of this may require considerable refinement of sampling techniques.

TABLE 4.

COMPARISON OF RESULTS OBTAINED FOR THE NUMBER OF RECORDS OF PREDACIOUS FUNGI FROM DIFFERENT TYPES OF MATERIAL

Source	Present work		Duddington (1951b)	
	No. of collections	No. of records	No. of collections	No. of records
Leaf mould	76	70	76	21
Rotting wood	7	6	10	12
Decaying plant parts	30	7	13	17
Moss	19	10	20	39
Dung	11	0	11	11
Totals	143	93	130	100

There seems little doubt that the number of predacious fungi reported in the present paper would be increased substantially by a more extensive and detailed investigation. Since the attention of mycologists was directed towards this interesting group by the studies of Drechsler in America, it has been shown that

these organisms, far from being rare curiosities are, in fact, relatively common. The possibilities of adapting their mode of nutrition to the control of plant-pathogenic eelworms has already been investigated, and there are indications that they may be efficacious as agents of biological control. The results of studies on this aspect have been summarised by Duddington (1957) who describes the experiments which have been carried out on nematodes parasitic on animals and various commercial crops. Although the results of several of these trials are rather equivocal, there are reasons for supposing that further investigations would be profitable. Certainly there is little doubt that further research is required to resolve the many problems concerned with the biology of this group of organisms.

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The Flora of Great Cumbrae Island (Firth of Clyde).

By W. W. Fletcher and D. J. Martin
(Botany Department, West of Scotland Agricultural College, Glasgow).

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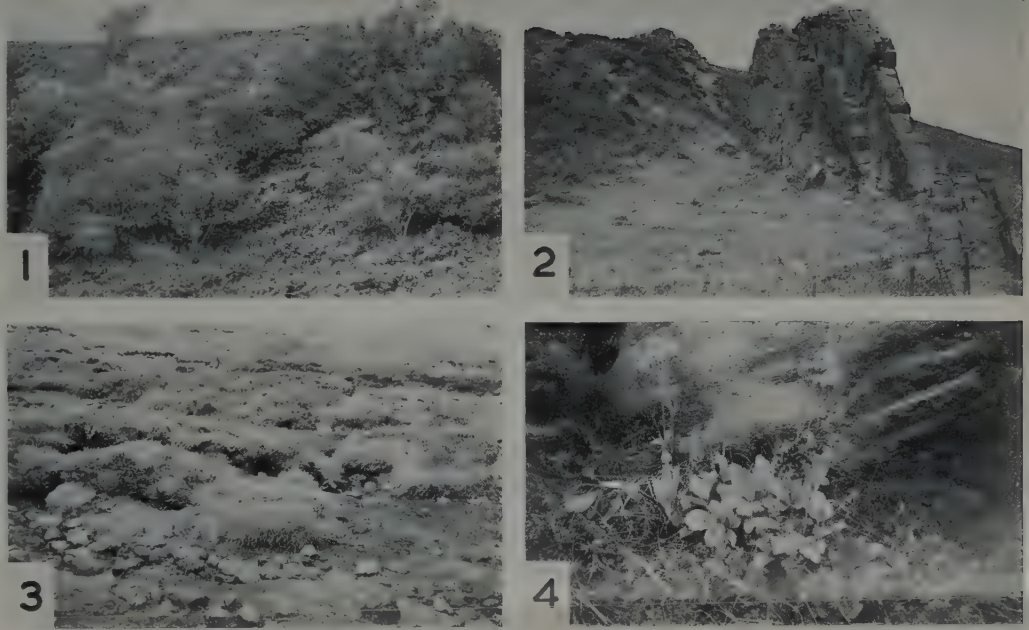
INTRODUCTION.

Great Cumbrae Island lies south-east of the Island of Bute in the Firth of Clyde. The island is about eleven miles in circumference, with an area of approximately 3,120 acres. According to Sutherland (1926), the greater part of the island is formed of the Upper Old Red Sandstone Series (for the most part rough, pebbly red sandstones). The southern part of the island, around Millport Bay, is composed of Lower Carboniferous rocks. One striking geological feature of the island is the number of dykes of intrusive igneous rock of Carboniferous age, mostly lying in a north-west to south-east direction. The best known is Lion Rock, a prominent landmark in the south-east part of Cumbrae.

The climate may be described as mild and moist; the mean yearly rainfall for the period 1916-1954 was 45·2 inches (S.M.B.A., 1956), for 1955 it was 39·7 inches; 1956, 38·0 inches; 1957, 42·5 inches; and 1958, 42·7 inches (H. T. Powell, personal communication). The mean January and July air temperatures for 1949-1953 were respectively 4·9° C. and 14·9° C. (Barnes, 1955).

Except at Fintray Bay, where there is a short stretch of sandy beach with sand-dunes behind, the foreshore round the island is rocky. This rocky foreshore gives way inland to a raised beach of fresh-water marshland, most of which is very wet due to the flow of water from the steep slopes above. It is noticeable that where the slope is gentle, the ground below is drier, and in some places, e.g. Fair Haven and west of the town of Millport, such land has been cultivated. A feature of the island is the well-wooded slopes rising rather sharply from the marshes to a height of 100-200 feet where they give way to moorland and heath, some of which has been converted to farmland. Along the road north-eastwards from the Marine Station it can be seen that for the first mile the tree slopes are dominated largely by Elder (*Sambucus nigra*). Other trees and shrubs present are Alder (*Alnus glutinosa*), Ash (*Fraxinus excelsior*), Sycamore (*Acer*



1.—The wooded slope above Area 1, rising sharply from marsh through bracken and scrub to moorland.
2. The Lion Rock, from the south. An intrusive igneous dyke, carrying a flora of Rock Pennywort and English Stonecrop as co-dominants.
3.—Salt marsh at Portachur, showing the pads which are covered at high tide.
4.—*Ligusticum scoticum* L. (Scotch Lovage) in its typical habitat sheltered by overhanging rock.

pseudoplatanus), Oak (*Quercus robur*), Hazel (*Corylus avellana*), Hawthorn (*Crataegus monogyna*), Sloe (*Prunus spinosa*), Gorse (*Ulex europaeus*), Broom (*Sarothamnus scoparius*), Ivy (*Hedera helix*) and Bracken (*Pteridium aquilinum*). In the second mile Alder is dominant with Oak, Rowan (*Sorbus aucuparia*), Birch (*Betula verrucosa*), Willow (*Salix* sp.), Hawthorn, Dog Rose (*Rosa canina*), Elder, Ash, Sycamore, Sloe and Honeysuckle (*Lonicera periclymenum*). The patch of trees south of Fair Haven consists of Elder, Birch, Alder, Oak, Rowan, Sloe and Hawthorn. At Fair Haven the belt of trees is composed of, primarily, Sycamore and Alder with Ash, Elm (*Ulmus* sp.), Horse Chestnut (*Aesculus hippocastanum*), Beech (*Fagus sylvatica*), Rowan, Birch, Hawthorn, Sloe, Ivy, Rhododendron (*Rhododendron ponticum*), Broom, Privet (*Ligustrum vulgare*), and Scots Pine (*Pinus sylvestris*). Past the monument there are Sycamore, Scots Pine, Alder and Rowan. Greycraig Wood contains mainly Sycamore and Ash with Birch, Oak, Hawthorn and Scots Pine. At the 'Indian Rock' there are many Rowans with Birch, Alder, Oak, Elder, Willow, Beech, Ash, Sycamore, Bramble, Hawthorn, Bracken, Ivy and Dog Rose also present. The dominant trees in the Fintray Bay Plantation are Alder and Sycamore, with White Poplar (*Populus alba*), Ash, Dog Rose, and Scots Pine also present. The woods past Fintray are mainly of Hazel, with Birch, Ash, Willow, Rowan, Oak, Elder and Sycamore.

One of the main attractions to the botanist is that the island offers such a variety of vegetation types within a small area. There are rocky foreshores, salt-marshes, fresh-water marshes (some of which may be washed with salt-water spray on occasions), woodlands, arable land, moorlands and heath, and small fresh-water lochs. Sutherland (1926) has described the vegetation of the island from an ecological aspect dealing mainly with the dominants to be found. In the present paper, as well as making fairly full lists of plants growing in various areas, we have also attempted an ecological study of the more interesting habitats. The lists are, no doubt, far from complete, but we publish them as a basis for future botanical work on the island. The lists are restricted almost wholly to the higher plants. They were compiled with the aid of a party of students (to whom due acknowledgment is made at the end of this paper) during a period of one week in July 1957 and two weeks in June-July 1958.

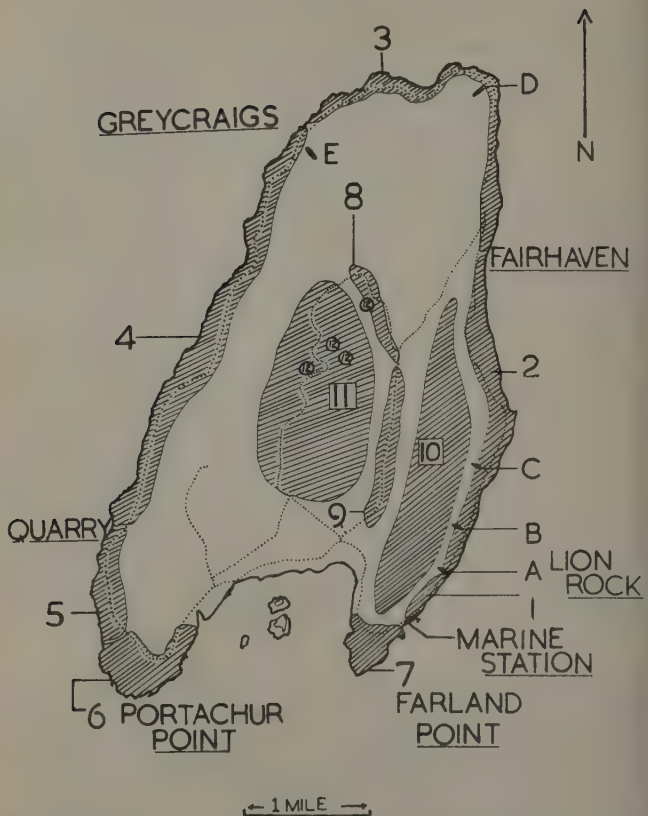


FIG. 1.—The numbers 1-12 indicate the position of the surveyed areas; the letters A-E indicate the position of the rock outcrops surveyed; dotted lines indicate roads.

The botanical names, with the exception of the orchids, are according to Clapham, Tutin and Warburg (1952). The orchids are named from Summerhayes (1951). The numbers 1, 2, 3, 4, etc., after each plant name refer to the areas (see Map, Fig. 1) in which the plant was found growing, according to the following key:—

Area 1 Marine Station to Lion Rock

On the landward side of the road, this area consists of a raised beach, facing south-east and kept in a moist condition by water draining off the upper moor. Within it there are raised patches of drier ground on which heath vegetation occurs while the final 15-20 yards to the Lion Rock are quite dry and like hill-pasture in quality of flora. Generally, however, the area is marshy with Sedges (*Carex* spp.), Rushes (*Juncus* spp.), Yellow Flag (*Iris pseudacorus*), Sundew (*Drosera rotundifolia*), Butterwort (*Pinguicula vulgaris*), and many *Orchis* species in season.

Area 2 Lion Rock to Fair Haven (roadside)

This area consists of rocky foreshore with bays at intervals, and the outermost edge of the raised beach along which runs the roadway. In parts, the foreshore and beach are marshy, both also being subject to salt-water spray. On the landward side the area is at first steep and tree-covered with Oak, Birch, Alder, Hawthorn and Elder. Later this side becomes lower and arable. Bracken is noticeable on both sides of the area, with Bramble, Willow and Water Dropwort (*Oenanthe crocata*) in the wetter areas.

Area 3 Fair Haven to "Grey Craigs" (north-east Cumbrae).

This area comprises the roadside verges, lower inland slopes and shore areas within the above limits. The rock formation and exposure is as in Area 2. On the landward side a Sycamore/Elder/Ash/Oak complex gives way to arable ground, in its turn being superseded by dry moor with Bracken and scrub. The foreshore is rocky with Whin, Bramble, Honeysuckle and Bracken on the drier areas. At the northernmost tip of the island the sandy foreshore gives way to salt marsh formation, while inland damp pasture with Jointed Rush (*Juncus articulatus*) and *Orchis* spp. forms the main vegetation. Gorse and Juniper (*Juniperus communis*) are also found here, with Cotton Grass (*Eriophorum* spp.) in some parts.

Area 4 "Grey Craigs" to Quarry of Area 5

This area is the continuation of the foreshore and nearby areas on the western side of the island. On the shore side there are many damp areas with a luxuriant growth of Water Dropwort. Drier patches here have Cotton Grass, rushes and buttercups.

Landwards, the marshy part of Area 3 gives way to scrub woodland at Fintray Bay with Alder and Bracken. Bog Myrtle (*Myrica gale*), Gorse and Juniper are the main components of the scrub where the ground is wet.

Area 5 Roadside from Quarry to Portachur Point

This area contains rough pasture land with some marsh, the latter limited by roadways and arable fields. A large marsh occurs at the end of the area, dominated by Yellow Flag, while the inner side of the roadway is marsh for its entire length, limited eastwards by the Doughend Brae.

Area 6 Portachur Point

An area of old red sandstone, facing south-east. On its inward parts the area rises to a sandy bank on which close-knit Fescue turf is dominant. Along its length, and above the water-line there are small raised patches colonised by species capable of withstanding frequent and complete inundation by sea water, these patches coalescing at the eastern end to form a salt-marsh association.

Area 7 Farland Point and foreshore to Lion Rock

Similar in rock structure, aspect and exposure to Area 6. On the rock itself there are pockets of soil in which grow plants suited to the environment, such as Sea Pink (*Armeria maritima*) and Sea Plantain (*Plantago maritima*). Further back from the rock and from the roadway outwards, the ground is mostly dry with a coarse type of vegetation, containing patches of marshy ground distinguishable by their flora of Water Dropwort.

Area 8 Roadside-Inner Circle Road

A small area consisting of the main road verge above the Standing Stone Plantation. The verges are narrow and on the inner side are steep and water-washed, with a flora of typically arable land weeds. At the upper end of the area is a gravel-bottomed quarry in the cliff face.

Area 9 Ninian Brae Woods to Standing Stone Plantation

Ninian Brae is formed along the site of a north-south fault in old red sandstone, now lying against carboniferous rocks. The face is steep and well-drained with a few marshy patches at the foot. At the southern end is a natural tree population, but further north this gives way to a Pine/Spruce (*Pinus sylvestris*/*Picea*

abies) plantation. At the most northerly portion arable land and scrub are encountered.

Area 10 Upper Moor-Fair Haven to Marine Station

This area is of typical upland hill pasture, with occasional swampy patches in the hollows, colonised by an aquatic vegetation. Short Heather (*Calluna vulgaris*) covers an appreciable part of the area and some of the hollows contain a dense growth of bracken. The area is limited at its southern boundary by the almost sheer faces of sandstone and basaltic dykes behind the Marine Station.

Area 11 Moorland

This area comprises all the moorland within the Circle Road. Most of it is covered with a Callunetum/Ericetum association, which is regularly burned, while other parts are of Sphagnetum or Polytrichetum.

Area 12 Fresh Water Pools

These are four in number, varying considerably in depth and flora. The first, south-east of Tonnel Hill, is fairly deep and appears to be a catchment pool. The second (Minnimoer) is near the highest point of the island, shallow over most of its area and draining south-west into a marsh. The third (Wee Minnimoer) lies further south-west and again is a catchment pool. The last is a small pool lying immediately south-east of Minnimoer.

LIST OF PLANTS AND THEIR LOCALITIES.

Equisetaceae	Equisetum fluviatile L. (3, 5, 9, 12), E. arvense L. (1, 2, 3, 6, 7, 8, 9), E. sylvaticum L. (3, 6, 8, 9).
Polypodiaceae	Pteridium aquilinum (L.) Kuhn (1, 2, 3, 4, 9, 11); Blechnum spicant (L.) Roth (2, 11); Phyllitis scolopendrium (L.) Newm. (2, 9); Asplenium adiantum-nigrum L. (2), A. trichomanes L. (2); Dryopteris filix-mas (L.) Schott (2, 9); Polypodium vulgare L. (1, 9).
Pinaceae	Picea abies (L.) Karst. (9); Larix decidua Mill. (9); Pinus sylvestris L. (9).
Cupressaceae	Juniperus communis L. (3).
Ranunculaceae	Caltha palustris L. (1, 12); Ranunculus acris L. (1, 3, 10, 11), R. repens L. (1, 4, 6, 7, 9, 10, 12), R. bulbosus L. (2, 6, 7), R. lingua L. (4), R. flammula L. (2, 4, 7, 10, 11, 12), R. lenormandi F. Schultz (2, 4), R. ficaria L. (9).

Nymphaeceae	Nymphaea alba L. (12).
Papaveraceae	Papaver dubium L. (5).
Fumariaceae	Fumaria officinalis L. (6).
Cruciferae	Brassica rapa L. (6, 7); Sinapis arvensis L. (5); Raphanus raphanistrum L. (9); Lepidium latifolium L. (6); Cardaria draba (L.) Desv. (6); Capsella bursa-pastoris (L.) Medic. (2, 5, 9); Cochlearia officinalis L. (6, 7); Cardamine pratensis L. (5, 7, 10, 11), C. amara L. (9); Nasturtium officinale R.Br. (1, 9); Rorippa islandica (Oeder) Borbas (3, 12).
Violaceae	Viola canina L. (8, 9), V. palustris L. (11).
Polygalaceae	Polygala vulgaris L. (2, 4, 8, 10).
Hypericaceae	Hypericum androsaemum L. (2, 5), H. tetrapterum Fr. (2, 5), H. humifusum L. (9), H. pulchrum L. (9).
Caryophyllaceae	Silene cucubalus Wibel (3, 7), S. maritima With. (7); Melandrium rubrum (Weig.) Garcke (1, 2, 3, 4, 9); Lychnis flos-cuculi L. (2, 3, 4, 7, 8); Cerastium vulgatum L. (1, 4, 7); Stellaria media (L.) Vill. (1, 2, 3, 6, 8, 9, 11), S. holostea L. (1, 2, 4, 9, 12); Sagina maritima Sm. (7), S. procumbens L. (2, 3, 4, 5, 7, 10, 11); Honkenya peploides (L.) Ehrh. (3, 4, 6); Spergula arvensis L. (3, 5, 9, 10); Spergularia marginata (DC.) Kitte (6).
Chenopodiaceae	Chenopodium bonus-henricus L. (6), C. album L. (2, 3, 6, 7); Atriplex glabriuscula Edmonst. (2, 3, 4, 6), A. sabplosa Rouy. (3, 4); Seuda maritima (L.) Dum. (6).
Malvaceae	Malva sylvestris L. (1, 3).
Linaceae	Linum catharticum L. (7).
Geraniaceae	Geranium molle L. (5), G. robertianum L. (2, 9); Erodium cicutarium L. (3).
Oxalidaceae	Oxalis acetosella L. (1, 5, 9, 10).
Aceraceae	Acer pseudoplatanus L. (2, 3, 4, 9).
Hippo-castanaceae	Aesculus hippocastanum L. (3, 9).
Papilionaceae	Ulex europaeus L. (1, 2, 3, 7, 9); Sarothamnus scoparius (L.) Wimmer. (2, 3, 8, 9); Trifolium pratense L. (1, 2, 3, 4, 6, 8, 10, 12), T. repens L. (1, 2, 3, 4, 6, 7, 8, 9, 10, 11), T. dubium Sibth. (1, 2, 3, 4, 6, 8); Anthyllis vulneraria L. (6); Lotus corniculatus L. (2, 3, 4, 6, 7, 8, 9, 10, 11), L. uliginosus Schkuhr (1, 2, 3, 4, 7, 9, 10, 12); Vicia cracca L. (3, 4, 6, 7), V. sepium L. (1, 2); Lathyrus pratensis L. (3, 6, 7, 9), L. montanus (L.) Bernh. (3, 6, 7).

Rosaceae	Filipendula ulmaria (L.) Maxim. (1, 2, 3, 4, 6, 7, 9, 12); Rubus idaeus L. (2, 7, 9), R. fruticosus L. (1, 3, 4, 6, 7, 8, 9, 12); Potentilla palustris (L.) Scop. (5, 6, 12), P. anserina L. (1, 2, 3, 4, 6, 7, 8, 9), P. erecta (L.) Rausch. (1, 2, 3, 4, 7, 8, 9, 10, 11), P. anglica Laich. (2, 3, 10), P. reptans L. (6); Fragaria vesca L. (2); Geum urbanum L. (9); Agrimonia eupatoria L. (2, 6), A. odorata (Gouan) Mill (2); Rosa spinosissima L. (2, 4, 5, 8, 9), R. canina L. (2, 4, 7); Prunus spinosa L. (2, 3); Crataegus monogyna Jacq. (2, 3, 4, 9); Sorbus aucuparia L. (3, 4, 9, 11).
Crassulaceae	Sedum anglicum Huds. (2, 3, 4, 5, 6, 7), S. acre L. (6); Umbilicus rupestris (Salsb.) Dandy (1).
Saxifragaceae	Saxifraga hypnoides L. (2, 3, 5).
Parnassaceae	Parnassia palustris L. (2, 3, 7).
Droseraceae	Drosera rotundifolia L. (1, 2, 3, 4, 7, 11, 12).
Lythraceae	Peplis portula L. (2); Lythrum salicaria L. (3, 4).
Onagraceae	Epilobium parviflorum Schreb. (1), E. adnatum Gris. (9), E. obscurum Schreb. (2, 3, 9, 11, 12), E. palustre L. (1); Chamaenerion angustifolium (L.) Scop. (3, 4, 5, 12); Circaea lutetiana L. (4), C. alpina L. (2).
Haloragaceae	Myriophyllum alternifolium DC. (12).
Callitrichaceae	Callitriche verna L. em. Lonnr. (12).
Araliaceae	Hedera helix L. (1, 2, 3, 4, 5, 9).
Hydrocotylaceae	Hydrocotyle vulgaris L. (1, 4, 7, 11, 12).
Umbelliferae	Apium nodiflorum (L.) Lag. (1); Chaerophyllum temulum L. (2); Carum verticillatum L. (1, 2, 5, 7, 11, 12); Conopodium majus (Gouan) Lor. & Barr (2, 3, 5); Aegopodium podagraria L. (2, 6, 7, 9); Berula erecta (Huds.) Coville (1); Oenanthe crocata L. (2, 4, 5, 7, 9); Ligusticum scoticum L. (1, 7, 3); Angelica sylvestris L. (8, 12); Heracleum sphondylium L. (1, 2, 3, 4, 6, 7, 9), H. mantegazzianum Somm. and Lev. (6).
Euphorbiaceae	Mercurialis perennis L. (2).
Polygonaceae	Polygonum aviculare L. (6), P. bistorta L. (2, 3, 4, 6, 7, 9), P. amphibium L. (11), P. persicaria L. (2, 3, 6, 11), P. hydropiper L. (12), P. cuspidatum Sieb. & Zucc. (4, 6); Rumex acetosella L. (1, 2, 3, 5, 7, 8, 9, 10, 11), R. acetosa L. (1, 2, 4, 5, 8, 9), R. crispus L. (1, 3, 4, 6, 7), R. obtusifolius L. (2, 5, 9).
Urticaceae	Urtica dioica L. (1, 3, 4, 9, 10).
Ulmaceae	Ulmus glabra Huds. (3, 9).
Myricaceae	Myrica gale L. (3, 4).
Betulaceae	Alnus glutinosa (L.) Gaertn. (2, 3, 4, 9); Betula verrucosa Ehrh. (2, 4).
Corylaceae	Corylus avellana L. (2, 4).
Fagaceae	Fagus sylvatica L. (3, 4, 9); Quercus robur L. (2, 4, 9).

Salicaceae	Salix spp. (1, 2, 4, 8); Populus alba L. (4).
Ericaceae	Rhododendron ponticum L. (3, 9); Calluna vulgaris (L.) Hull (1, 2, 3, 4, 7, 8, 9, 10, 11); Erica tetralix L. (1, 2, 3, 4, 5, 7, 8, 9, 11), E. cinerea L. (1, 2, 3, 4, 7, 8, 10, 11); Vaccinium myrtillus L. (7, 8, 10, 11); Oxycoccus palustris Pers. (4).
Empetraceae	Empetrum nigrum L. (7).
Plumbaginaceae	Armeria maritima (Mill.) Willd. (2, 3, 4, 6, 7).
Primulaceae	Primula vulgaris Huds. (2); Lysimachia nemorum L. (1, 2, 4, 9), L. nummularia L. (9); Anagallis arvensis L. (6), A. tenella (L.) Murr. (1, 2, 6, 10, 12); Glaux maritima L. (3, 4, 6, 7); Samolus valerandi L. (3).
Oleaceae	Fraxinus excelsior L. (2, 3, 9); Ligustrum vulgare L. (3).
Gentianaceae	Gentianella campestris (L.) H. Sm. (8).
Menyanthaceae	Menyanthes trifoliata L. (1, 4, 12).
Boraginaceae	Symphytum officinale L. (5); Myosotis arvensis (L.) Hill (1, 11), M. discolor Pers. (1, 2, 4, 8, 10).
Convolvulaceae	Convolvulus arvensis L. (1); Calystegia sepium (L.) Roem. & Schult. (3, 6, 7).
Solanaceae	Solanum nigrum L. (5).
Scrophulariaceae	Verbascum thapsus L. (2, 4); Linaria vulgaris Mill (5); Scrophularia nodosa L. (2, 4); Digitalis purpurea L. (1, 2, 5, 8, 10); Veronica beccabunga L. (4, 7, 9, 11), V. scutellata L. (1), V. officinalis L. (9), V. chamaedrys L. (2, 3, 4, 6, 7, 9), V. anagallis-aquatica L. (1); Pedicularis palustris L. (7, 10, 11, 12), P. sylvatica L. (1, 7, 11, 12); Rhinanthus minor Ehrh. (3, 6, 7, 9, 12); Euphrasia officinalis agg. (1, 2, 3, 4, 6, 7, 8, 9, 10); Odontites verna (Bell.) Dum. (4, 8).
Lentibulariaceae	Pinguicula vulgaris L. (1, 2); Utricularia minor L. (12).
Labiatae	Mentha arvensis L. (5), M. × verticillata L. (1), M. aquatica L. (1, 2, 4, 8, 12); Lycopus europaeus L. (2, 3, 4); Origanum vulgare L. (4); Thymus serpyllum L. (1, 2, 3, 4, 6, 7, 11); Prunella vulgaris L. (1, 2, 3, 5, 8, 9, 12); Stachys palustris L. (2, 9), S. sylvatica L. (3, 9); Lamium amplexicaule L. (5), L. purpureum L. (1, 2, 3, 5), L. album L. (9); Galeopsis tetrahit L. (2, 5, 9); Glechoma hederacea L. (2, 9); Scutellaria galericulata L. (2, 4); Teucrium scorodonia L. (2, 3, 5, 7, 8, 9); Ajuga reptans L. (11).
Plantaginaceae	Plantago major L. (2, 5, 6, 7, 9), P. lanceolata L. (6, 7, 11, 12), P. maritima L. (2, 3, 4, 6, 7), P. coronopus L. (2, 4, 7).
Campanulaceae	Campanula rotundifolia L. (1, 2, 3, 4, 6, 8, 9, 12).

Rubiaceae — Galium cruciata (L.) Scop. (2, 3, 4, 7, 8, 9), G. verum L. (6, 7, 11), G. hercynicum Weigel (2, 7, 9), G. aparine L. (2, 3, 4, 6, 7, 9, 11).

Caprifoliaceae — Sambucus nigra L. (1, 2, 4, 5), Lonicera periclymenum L. (2, 4, 7, 9).

Valerianaceae — Valeriana officinalis L. (3).

Dipsaceae — Succisa pratensis Moench (2, 4, 7).

Compositae — Senecio jacobaea L. (1, 2, 3, 4, 6, 7, 8, 9, 12), S. aquaticus Hill (4), S. viscosus L. (4), S. vulgaris L. (2, 5, 6, 7); Tussilago farfara L. (2, 4, 5, 7); Petasites hybridus (L.) Gaertn. Mey and Schreb. (3); Gnaphalium uliginosum L. (9); Solidago virgaurea L. (2, 3); Aster tripolium L. (3, 6); Bellis perennis L. (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12); Eupatorium cannabinum L. (2, 9); Achillea millefolium L. (1, 2, 3, 4, 6, 9, 12), A. ptarmica L. (1, 2, 3, 6, 8, 9, 11, 12); Matricaria maritima L. (4, 6, 7), M. matricarioides (Less.) Porter (3, 5, 9, 11, 12); Chrysanthemum segetum L. (6), C. leucanthemum L. (9); Arctium minus (Hill) Bernh. (1, 2, 6, 9); Cirsium vulgare (Savi) Ten. (1, 2, 3, 4, 9, 10), C. palustre (L.) Scop. (2, 3, 4, 7, 8, 10, 11), C. arvense (L.) Scop. (1, 2, 3, 4, 8, 9, 10, 11, 12), C. heterophyllum (L.) Hill (1, 2); Centaurea nigra L. (2, 3, 4, 6, 7, 8, 9); Lapsana communis L. (6); Hypochaeris radicata L. (2, 7); Sonchus arvensis L. (2, 3, 9), S. oleraceus L. (1, 2, 3, 6, 7, 9), S. asper (L.) Hill (1); Hieracium pilosella L. (1, 3, 4, 6, 7, 9, 11); Crepis capillaris (L.) Wallr. (9); Taraxacum officinale agg. Web. (2, 3, 6, 7, 9).

Alismataceae — Alisma plantago-aquatica L. (12); Baldellia ranunculoides (L.) Parl. (1, 5).

Juncaginaceae — Triglochin maritima L. (6, 7).

Potamogetonaceae — Potamogeton natans L. (12), P. lucens L. (12).

Liliaceae — Narthecium ossifragum (L.) Huds. (1, 2, 4, 7, 11).

Juncaceae — Juncus squarrosus L. (2, 7, 9, 10, 11), J. gerardi Lois. (6), J. inflexus L. (2), J. effusus L. (1, 3, 4, 5, 7, 9, 10, 11, 12), J. conglomeratus L. (3, 7, 10), J. maritimus Lam. (6), J. articulatus L. (1, 2, 3, 4, 5, 7, 10, 12), J. bulbosus L. (12); Luzula sylvatica (Huds.) Gaud. (2, 9), L. campestris (L.) DC. (2, 11).

Iridaceae — Iris pseudacorus L. (1, 2, 3, 4, 6, 7, 9).

Orchidaceae — Listera ovata (L.) R.Br. (2, 7); Orchis fuchsii Druce (4, 5), O. ericetorum E. F. Linton (1, 2, 3, 4, 5, 7, 11), O. purpurella T. and T. A. Steph. (1, 2, 3, 4, 5, 7), O. latifolia L. sec. Pugsl. (1, 3, 4); Platanthera chlorantha (Cust.) Rchb. (2, 3, 4, 7), P. bifolia (L.) Rich. (2, 3, 4, 7); Gymnadenia conopsea (L.) Rich. (1, 3).

Lemnaceae	Lemna trisulca L. (10).
Sparganiaceae	Sparganium simplex Huds. 12.
Cyperaceae	Eriophorum angustifolium Honck. (1, 7, 11, 12), E. vaginatum L. (1, 7, 11, 12); Trichophorum caespitosum (L.) Hartman (7, 11, 12); Eleocharis palustris ssp. palustris (L.) R.Br. emend. Roem. and Schult. (1, 12); Schoenus nigricans L. (1, 6); Carex hostiana DC. (9), C. extensa Good. (6), C. rostrata Stokes (11), C. vesicaria L. (1, 11), C. acutiformis Ehrh. (12), C. pendula L. (9, 10), C. panicea L. (1, 7), C. hirta L. (8), C. nigra (L.) Reichard (1, 7, 11), C. vulpina L. (2), C. arenaria L. (4, 5), C. lachenalii Schkuhr (7), C. pulicaris L. (5, 11).
Hydrocharitaceae	Elodea canadensis Michx. (12).
Gramineae	Molinia caerulea (L.) Moench (2, 4, 7, 11); Sieglingia decumbens (L.) Bernh. (7), Glyceria fluitans (L.) R.Br. (4); Festuca pratensis Huds. (5, 6, 7), F. rubra L. (2, 3, 4, 6, 7, 9, 11), F. ovina L. (1, 7, 11); Lolium perenne L. (3, 7, 9); Puccinellia maritima (Huds.) Parl. (6); Poa annua L. (1, 2, 3, 4, 5, 6, 7, 8, 9, 10), P. pratensis L. (9), P. trivialis L. (5, 6, 11); Dactylis glomerata L. (1, 3, 6, 7, 9); Cynosurus cristatus L. (1, 2, 6, 9, 12); Bromus mollis L. (2); Agropyron caninum (L.) Beauv. (4), A. repens (L.) Beauv. (3, 4, 6, 9); Elymus arenarius L. (4, 7); Trisetum flavescens (L.) Beauv. (6); Arrhenatherum elatius (L.) J. and C. Presl. (2, 3, 4, 6, 7); Holcus lanatus L. (1, 2, 7, 9), H. mollis L. (1, 2, 3, 6, 9, 10, 11), Deschampsia caespitosa (L.) Beauv. (2, 3, 7, 9), D. flexuosa (L.) Trin. (2, 5, 7, 9, 10, 11); Aira caryophyllea L. (11); Ammophila arenaria (L.) Link (4); Agrostis stolonifera L. (3); Phleum pratense L. (5); Alopecurus myosuroides Huds. (7), A. pratensis L. (5), A. geniculatus L. (5); Anthoxanthum odoratum L. (1, 2, 3, 5, 7, 9, 10, 11, 12); Nardus stricta L. (2, 7, 10, 11).

DISCUSSION.

Although the plants are listed and named according to Clapham, Tutin, and Warburg (1952), much of the preliminary identification was done using Lee (1933). The latter was especially useful for information about the occurrence of a plant in the Clyde area in general. According to Lee the following plants which were found are uncommon or rare in the Clyde area:

Phyllitis scolopendrium (L.) Newm., *Lepidium latifolium* L., *Atriplex sabulosa* Rouy, *Lythrum salicaria* L., *Peplis portula* L., *Apium nodiflorum* (L.) Lag., *Lysimachia nummularia* L., *Anagallis*

rvensis L., *A. tenella* (L.) Murr., *Gentianella campestris* (L.) H. m., *Convolvulus arvensis* L., *Lycopus europaeus* L., *Origanum ulgare* L., *Lamium amplexicaule* L., *Eupatorium cannabinum* L., *uncus inflexus* L., *J. maritimus* Lam., *Carex acutiformis* Ehrh., *'. pendula* L., *C. vulpina* L., *Trisetum flavescens* (L.) Beauv., *lopecurus myosuroides* Huds.

Orchids grow in profusion on the island, particularly in the marshes and on the ground bordering the marshes. In the wetter reas the Spotted Orchis (*Orchis fuchsii*), the Marsh Orchis *Orchis purpurella*), and the Early Marsh Orchis (*Orchis latifolia*) ccur in great numbers. The Greater and Lesser Butterfly Orchids *Platanthera chlorantha* and *P. bifolia*) and the Fragant Orchis *Gymnadenia conopsea*) are common on hummocks rising above he very wet areas and can be abundant in dry, rough pasture. The Heath Spotted Orchis (*Orchis ericetorum*) is very abundant in he drier parts of the marshes and up to and into the dry heather reas. Only five specimens of the Common Twayblade (*Listera ovata*) were found, all of them in very rough grassland. There ppears to be a fair degree of hybridization among the *Orchis* spp. growing in the marshes.

THE ECOLOGY OF PARTICULAR AREAS.

(1) *ROCK OUTCROPS.*

(A) *LION ROCK* (Map reference A).

The Lion Rock is an intrusive basaltic dyke embedded in Old Red Sandstone. The soil cover is thin and the typical plants of the rea are those adapted to arid conditions. They are typified by Rock Pennywort (*Umbilicus rupestris*) which is the most abundant plant, and by English Stonecrop (*Sedum anglicum*), both of which have thick fleshy stems and leaves. In addition, Cat's Ear Hawkweed (*Hieracium pilosella*), Wood Sage (*Teucrium scorodonia*) and Sheep's Sorrel (*Rumex acetosella*), typical of poor soil conditions, are found in considerable numbers. The grasses are represented by a few clumps of Yorkshire Fog (*Holcus lanatus*) and a single specimen of Heath Grass (*Sieglingia decumbens*).

Further inland, along the line of the dyke, the flora changes little although there is an increase in the depth of the soil. Here Bracken (*Pteridium aquilinum*) is found and in the open places Wild Thyme (*Thymus serpyllum*), Common Speedwell (*Veronica*

officinalis), and Heath Bedstraw (*Galium hercynicum*) are frequent. At points the soil gives way to rock and in the rock crevices English Stonecrop occurs regularly. On the upper faces of the dyke there are also considerable quantities of Fine-leaved Heath (*Erica cinerea*).

Over those areas of ground where the cover is complete the main plants are the closely matted Sheep's Fescue (*Festuca ovina*), Sweet Vernal Grass (*Anthoxanthum odoratum*) and interspersed through them is Sheep's Sorrel.

(B) *ROCK OUTCROP 2* (Map reference B).

This is a small outcrop of igneous rock surrounded by Old Red Sandstone which provides a reasonable depth of soil on the east side where the principal vegetation is Bracken and Sheep's Fescue, particularly at the exposed base of the outcrop where the dyke has broken down. Other plants occurring there are Heath Bedstraw, Common Speedwell, Enchanter's Nightshade (*Circaea lutetiana*), English Stonecrop, Wood Sorrel (*Oxalis acetosella*) and Wood Sage. Higher up, at the end of the dyke is a growth of Ivy (*Hedera helix*). The centre region is quite bare rock and English Stonecrop, Sheep's Sorrel, Sweet Vernal Grass, and Sheep's Fescue are the main plants. The upper region carries Heather (*Calluna vulgaris*), English Stonecrop, Wild Thyme, Wood Sage, and Sheep's Sorrel. The top of the rock has a thin cover of soil which supports a large population of Heather and Sheep's Fescue, amongst which there is a small amount of Heath Bedstraw and Tormentil (*Potentilla erecta*). The west face of the rock has less soil than the east but, nevertheless, most of the species listed can be found, Wood Sage and English Stonecrop being the most frequent.

(C) *ROCK OUTCROP 3* (Map reference C).

This rock outcrop is broken down to a considerable extent and covered by a reasonable depth of soil in some places. The principal vegetation is a scrub of Bramble (*Rubus fruticosus*), Dog Rose (*Rosa canina*) and Burnet Rose (*Rosa spinosissima*). On the lower slopes the grass cover is largely Sheep's Fescue with Bracken, Heath Bedstraw, and Tormentil. In places where the soil is not so deep there is Fine-Leaved Heath. Compared with the Lion Rock vegetation, the cover is more complete, shown by the com-

parative scarcity of Rock Pennywort and the great reduction in the number of colonies of English Stonecrop.

(D) *ROCK OUTCROP 4* (Map reference D).

This outcrop is very clearly defined and well exposed. There is very little soil present and fewer species of plants are found on this outcrop than on any of the others. Those that are found occur only infrequently and are plants typically associated with poor soil conditions, e.g. Sheep's Fescue, Sweet Vernal Grass, Wood Sage, and Rock Pennywort.

(E) *ROCK OUTCROP 5* (Map reference E)

The first part of this outcrop is only slightly above the level of the surrounding marsh land. The dominant plant is Sheep's Fescue with Bracken, Heather and Fine-leaved Heath. The other plants found, e.g. Birdsfoot Trefoil (*Lotus uliginosus*), Heath Spotted Orchis (*Orchis ericetorum*), and Wild Thyme occur singly or in isolated patches, although Heath Bedstraw and Tormentil are fairly widespread among the grassy patches.

(2) *HEATHER MOOR.*

Heather moor occupies much of the higher ground above 200 ft. It varies from very dry areas with typical heath vegetation to boggy areas and fresh water pools. The soil pH varies from 4·8 to 5·8. The moor is dominated largely by Heather (*Calluna vulgaris*) in good condition due to regular burning, with Cross leaved Heath (*Erica tetralix*) and Deer's Hair Sedge (*Trichophorum caespitosum*) very abundant. Molinia (*Molinia caerulea*) is a common grass and together with mosses—*Sphagnum* spp., *Hypnum* spp., *Polytrichum commune*—and lichens covers most of the remaining ground.

Other plants found, arranged roughly in order of frequency, were Heath Rush (*Juncus squarrosus*), Hare's tail (*Eriophorum vaginatum*), Bog Asphodel (*Narthecium ossifragum*), Bell heather (*Erica cinerea*), Cotton Grass (*Eriophorum angustifolium*), Common Sedge (*Carex nigra*), Wavy Hair grass (*Aira flexuosa*), Blaeberry (*Vaccinium myrtillus*), Lousewort (*Pedicularis sylvatica*), Heath Grass (*Sieglingia decumbens*), Tormentil (*Potentilla erecta*), Meadow Grass (*Poa trivialis*), Bladder Sedge (*Carex vesicaria*), Sundew (*Drosera rotundifolia*), Heath Spotted Orchis

(*Orchis ericitorum*), Sheep's Fescue (*Festuca ovina*) and Moor mat grass (*Nardus stricta*).

(3) *SALT MARSH* (*PORTACHUR*)

The salt marsh is made up of two parts with a total area of approximately $\frac{3}{4}$ acre. It is flooded at high tides. The underlying stratum consists of sedimentary rock; the soil is sandy and between the raised pads of vegetation, pools of sea water are frequent. The pH of the soil was 6·6-6·7. The salt content of the soil (determined by the silver nitrate method using K_2CrO_4 as indicator) was (a) 316 mg. per 100 g. of soil of a pad below the high tide mark consisting largely of Sea Poa (*Puccinellia maritima*); (b) 286 mg. per 100 g. of soil of a pad, at the average level of the High Water Spring Tides, consisting of Sea Plantain (*Plantago maritima*), Sea Milkwort (*Glaux maritima*), Thrift (*Armeria maritima*) and Sea Aster (*Aster tripolium*); (c) 103 mg. per 100 g. of soil of a raised pad slightly further inshore of Sea Arrow Grass (*Triglochin maritima*), Mud Rush (*Juncus gerardi*) and Thrift; (d) 8 mg. per 100 g. of soil above High Water Spring Tide level a patch of Sea Sandwort (*Honkenya peploides*); (e) 3 mg. per 100 g. of soil, above shore level of a Red Fescue (*Festuca rubra*) turf. Other species noted in the salt marsh were Silverweed (*Potentilla anserina*), Couch Grass (*Agropyron repens*), White Clover (*Trifolium repens*), Sand-spurrey (*Spergularia marginata*), Scurvy Grass (*Cochlearia officinalis*), and Orache (*Atriplex glabriuscula*).

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A Survey of the Bryophytes and Lichens of "The Burn", Kincardine.

By U. K. Duncan.

(Received, 20th November 1959.)

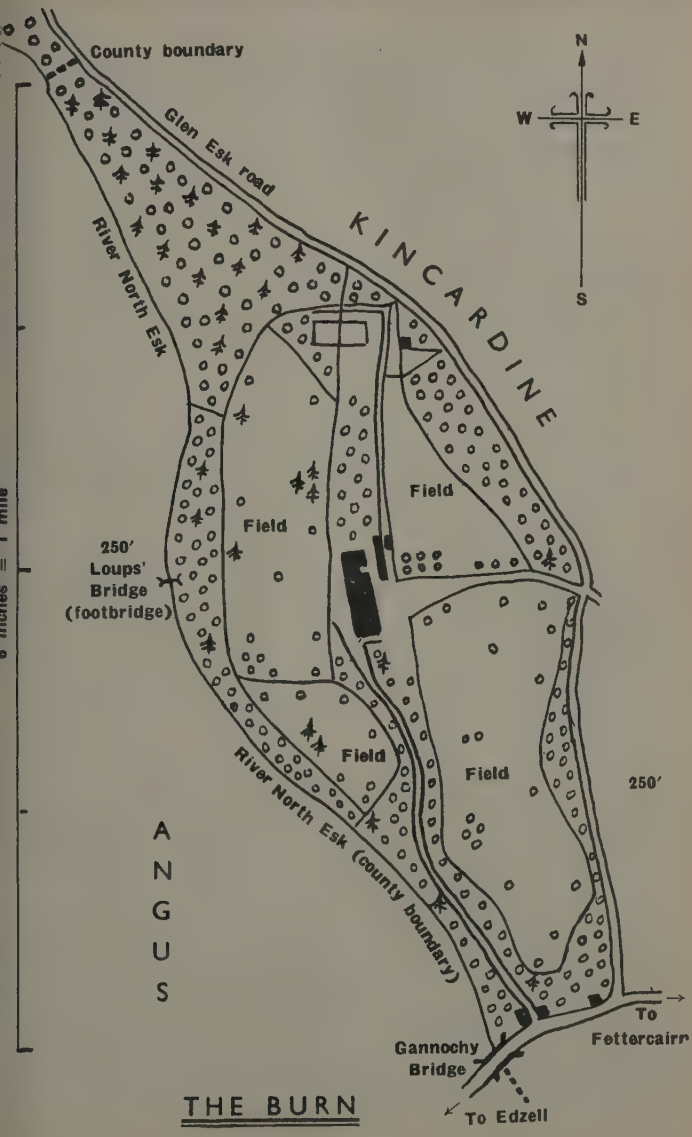
The Burn is situated at the foot of Glen Esk on the east, or Kincardineshire, side of the River North Esk, approximately a mile and a quarter north of Edzell. The present survey is confined to that part of the estate which is bounded on the west by the river and on the south and east by the motor-road from Gannochy* Bridge to the head of Glen Esk. The northern limit is set at the point where the county boundary crosses the river, the whole upper part of the glen lying wholly within the county of Angus.

The name *Burn* is believed to have been derived from the Gaelic word *bearna,* a gap, from the cleft made by the river as it emerges from the Grampians (Watt, J. C., *The Mearns of Old,* 1914), and not from the Scots word *burn,* as there is no stream of any appreciable size entering the river here.

Our area, which is approximately 1 mile from north to south and ½ mile from east to west at its widest point, is centred round a large mansion-house situated a few hundred yards from a picturesque gorge formed by the river cutting its way through a barrier of Old Red Sandstone. The whole area is densely wooded with the exception of four fields, and here too trees have been planted here and there for ornamental purposes. The altitude lies between 220 and 276 feet above sea-level, the 250 contour-line extending from the now disused Loups Bridge on the River North Esk across the estate south-eastwards to reach the Glen Esk road about a quarter of a mile from its most southerly point.

Although the altitude is too low for mountain plants (except those like *Alchemilla alpina, Saxifraga aizoides, Selaginella,* and the moss *Hygrohypnum dilatatum,* which have evidently been washed down by the river), the Burn has long been known for its bryophytes. Alexander Croall (1809-1885) appears to have been the first to collect liverworts and mosses in this area, but his work was chiefly carried out on the Angus section of the river, as shown by his numerous specimens labelled "The Burn, foot of

Gannochy in the 6-inch O.S. edition of 1928; *Gannachy* in the 1-inch O.S. Popular edition published in 1946.


County boundary
Glen Esk road
River North Esk
KINCARDINE
N
W
E
S
Field
Field
Field
Field
250'
Loups'
Bridge
(footbridge)
River North Esk (county boundary)
ANGUS
250'
To
Fettercairn
Gannochy
Bridge
To Edzell
THE BURN

Glen Esk, Forfar" in herbaria at the British Museum and in Edinburgh. His other records marked "Rocks at the Burn" or "Woods of the Burn," and included in *The Botanist's Guide to the Counties of Aberdeen, Banff and Kincardine* (Dickie, G. D., 1860), almost certainly belong to our area as defined above. Uncertainty as to which county the plant was collected in, does, however, exist in the case of certain old specimens from "N. Esk near Gannachie" (*sic*), no date or name of collector given, also others in various herbaria collected by A. Kerr, A. O. Black, etc. It should be noted, too, that Dickie's reference to *Gyalecta Acharii* Schaer., "By the Burn, east of Hill of Woodston" (Dickie, 1860, 274) indicates that there was another locality of the same name, apparently near St. Cyrus. All these dubious records have been omitted from the present survey.

Although no lists of bryophytes appear to have been published since 1860, a few later specimens from the Burn can be found in herbaria. As far as lichens are concerned, very little attention has hitherto been paid to the lichen flora of Kincardineshire at all, and no records from our area can be traced.

For the purposes of the present survey, it is proposed to divide the estate into three zones, namely River, Woodland and Policies, indicated by the letters R, W, and P, respectively. Plants belonging to the river zone will be confined to those growing on rocks in, or by, the North Esk, or on soil on these rocks and on the river banks. As the whole area is planted with trees, it has been decided to include under woodland all species found on trees whether by the river, in the main part of the wood, or throughout the policies, also plants growing on the ground in the woods. The policies will include the ground vegetation of the fields, drive, lawns and garden, as well as walls (including those of the mansion-house and cottages), also fence-posts—in fact, those habitats that are not "natural" but supplied by human agency.

It should be particularly noted that these zones to a certain extent overlap, and the fact that a plant may be listed under only one zone does not entirely exclude it from the other two, but indicates that (if found in the latter) it may be of very little importance there, such as certain corticolous lichens omitted from fence-posts because they are only found in a depauperate state. Another reason, of course, may be that the species has been overlooked in the other zones.

RIVER.

The geology of the basin of the upper North Esk has aroused interest for many years. In *A General View of the Agriculture of Kincardineshire or the Mearns* (Robertson, G., 1813) we find what may be the first reference to the geology of this particular section of the river: "At The Burn, by the banks of the North Esk, as it issues from the Grampians, there are entire rocks of this kind of stone (Jasper), also of Porphyry".

A more modern work, *The Stratigraphical Order of the Dalradian Schists near the Highland Border in Angus and Kincardine* (Anderson, J. G. C., 1942, *Trans. Geograph. Soc. Glasgow*, **20**, 223-227), mentions that "the lower part of the North Esk section is well known for its fine exposures of the Highland Border Series first described in detail by Barrow (1901). The section which begins at the fault cutting off the Highland Border Series a mile and three quarters above Gannochy Bridge and continues upstream to near Haughend, provides equally spectacular exposures of the Dalradian rocks for over a mile across the strike". Although our section of the river, extending for only a mile above the bridge, lies within the belt of Old Red Sandstone, the rocks in the gorge at this point are noticeably basic (as shown by the occurrence of such plants as *Barbula ferruginascens, Tortella tortuosa, Ctenidium molluscum, Peltidea aphthosa* and *Aspicilia calcarea*), and great blocks of schist have been carried down by the river from the upper basin to have an important effect on the flora.

WOODLAND.

Robertson (*loc. cit.*) states that before the Burn was planted with trees by Lord Adam Gordon in 1782, the estate was "in a state of the most abject sterility . . . a dreary desert", and eighteenth century maps also proclaim the treelessness of the whole region. Robertson quotes larch, Scots fir, beech, oak, ash and birch as being among the trees planted by Lord Gordon, and of such the woodland consists to-day, with the addition of a few trees of sycamore, wych elm, sweet chestnut, rowan, and a belt of self-sown alder along the river in the northern part of our area. Some of the original trees planted in 1782 probably survive to-day, notably in the fields near the mansion-house where some of the larches, at least, are of a great age.

The improvement to the soil by planting up the area with trees so as to build up and retain humus was well recognised at the time of the Survey, and no better example exists than at the Burn where Robertson (*loc. cit.*) noted that "the soil is indeed the most meagre that can well be conceived. It has all the appearance of having been left altogether bare of mould, or at least with so little that after it has accumulated for ages from the remains of such scanty vegetables as might have sprung up and alternately decayed upon the surface, there is hardly yet a single inch of earth where it is unaided by cultivation". It is worth recalling that Dr. Johnson, when passing through East Scotland with Mr. Boswell in 1773, deplored the absence of trees in that part of Britain. It may be that Johnson's severe strictures had some considerable influence on the local landowners, since many estates were planted up in the thirty or forty years following his visit. By 1813 Robertson estimated that 10,000 acres of woodland had been planted in Kincardineshire alone during the last twenty-five years.

At the Burn, a section of the wood in the northern part of the area covered by this survey has been felled recently, and is now replanted with young larch and pine. The whole woodland zone provides rich ground for the collector, particularly as regards the flora of the tree-trunks, where the purity of the air due to the absence of towns in the vicinity, and the constant moisture rising from the river gorge causes a particularly lush growth of bryophytes, and especially of lichens, mainly on the older trees. Most notable among the conspicuous plants of *Usnea, Alectoria, Ramalina, Evernia* and *Pertusaria* spp. on the latter, are perhaps the fine specimens of *Alectoria implexa,* found on beech in one part only of the wood. On the smaller trees, such as alder and rowan, along the river in the northern sector, species of *Ulota* and *Orthotrichum* are particularly well developed, as well as a number of the less conspicuous lichens such as the minute *Stenocybe byssacea,* found only on branches of alder overhanging the river.

On the rich leaf-mould below, laid down (as we learn from Robertson) in the last 178 years, has formed a thick growth of bryophytes of the familiar woodland types, mainly *Polytrichum, Dicranum, Mnium, Hypnum* and *Hylocomium* spp. The flora of the moist sides of ditches often repeats that of damp soil by the river (*Pellia fabbroniana, Fissidens taxifolius,* etc.) while that of

loose stones throughout the woods is similar to the flora of stone walls in the policies (*Rhacomitrium heterostichum, Lecidea* spp.). Here and there, in more open ground, colonies of lichens such as *Cladonia* thrive on tree-stumps and among heather.

POLICIES.

The mansion-house was built by Lord Adam Gordon, creator of the estate as we now know it, in 1791. The building has probably undergone some alterations since that date, but the present façade is the home of many lichens, such as *Parmelia fuliginosa, Lecanora dispersa, L. campestris, L. atra, Caloplaca pusilla, C. citrina, C. pyracea* and *Candelariella vitellina,* and these species are reproduced on cottages, garden walls, etc.

Two main types of walls exist: First, the well-built sandstone walls which adjoin the main entrances to the estate, and are damper than dwelling-houses and therefore more suitable for the growth of bryophytes. Here the lime provided by the mortar makes a good habitat for such species as *Encalypta streptocarpa, Aspicilia calcarea,* and *Gyalecta cupularis.* The other type of wall is the dry-stone dyke which is found commonly throughout the estate and along part of the Glen Esk road. The smooth rounded stones of which these are built are often of some kind of schist, perhaps collected originally from the river bed. They have a rather different flora from that of the sandstone, e.g. *Parmelia mougeotii* and *Verrucaria nigrescens,* and the turf with which they are usually partly overgrown provides a suitable habitat for many mosses and liverworts, among them *Diphyscium foliosum* (so common at the Burn) and *Lophozia hatcheri.*

Several ditches intersect the estate (becoming torrents in very wet weather), finally entering the river at various points; but no plants of interest have been noted in, or by, them except such as also occur more plentifully by the North Esk itself.

The ground flora of the fields (three of which are laid down, perhaps permanently, in grass, while the fourth and largest, to the east of the drive, is divided into three by temporary fences and generally cultivated by a rotation of crops) is of little interest except in so far as patches of moist soil provide suitable conditions for the growth of bryophytes of the type of *Ditrichum cylindricum, Ephemerum serratum* var. *minutissimum,* and many commoner species. Most of these are also to be found in garden ground.

I am very much indebted to Colonel D. C. Harland, proprietor of the Burn, for his kindness in giving me permission to undertake this survey. Finally, let me emphasise that it *is* only a survey, and lays no claim to be a complete flora. More remains to be done, chiefly on critical genera such as *Bryum* and *Usnea*.

In the lists the order and nomenclature are those of the following (with some later amendments):—

An Annotated List of British Hepatics (1958) *Trans. British Bryological Society*, **3**, 3.

An Annotated List of British Mosses (1950) *Trans. British Bryological Society*, **1**, 4.

Census Catalogue of British Lichens (Watson, 1953).

Sources for records are as follows:—

Dickie, G. (1860) *The Botanists's Guide to the Counties of Aberdeen, Banff and Kincardine* (1)
Herbarium, Aberdeen University Botany Department (2)
Herbarium, British Museum, London (3)
Herbarium, Royal Botanic Garden, Edinburgh (4)
Trans. British Bryological Society (1957), **3**, 2 (5)
Trans. British Bryological Society (1958), **3**, 3 (6)

(When no indication is given as to the collector, the record is my own.)

HEPATICS (LIVERWORTS)

CONOCEPHALUM CONICUM (L.) Dum. (R) Very common on damp rocks, also (W) (P) by the sides of ditches and drains.

LUNULARIA CRUCIATA (L.) Dum. (W) Damp ground, (P) garden paths, etc., locally common.

PREISSIA QUADRATA (Scop.) Nees (R) Damp rocks, common. (This is evidently the species referred to by Dickie as *Fegatella hemisphærica* Linn. (1) The older bryologists often included *Reboulia hemisphaerica* and *Preissia* under this name, thereby causing confusion. But Dickie's habitat, "Shady moist places", is unlikely for *Reboulia*).

MARCHANTIA POLYMORPHA L. (R) Damp rocks, frequent, sometimes submerged.

RICCIA SOROCARPA Bisch. (P) Bare moist soil in fields, etc., frequent in some years, apparently absent in others.

RICCARDIA LATIFRONS (Lindb.) Lindb. (W) Rotten logs in very damp situations, rare.

R. PALMATA (Hedw.) Carruth. (W) Rotten stumps or logs in very wet places, rare.

R. PINGUIS (L.) S. F. Gray (R) (W) (P) Very common in wet places, especially along the river.

PELLIA EPIPHYLLA (L.) Corda (W) Moist banks and ditch-sides, common.

P. FABBRONIANA Raddi (R) (W) (P) Very common on wet rocks, by ditch-sides, and on the ground in damp places throughout.

METZGERIA FURCATA (L.) Dum. (R) (W) (P) Wet rocks and walls, trees and stumps, throughout the area.

Ptilidium pulcherrimum (Weber) Hampe (W) Only seen on one tree-stump, probably more frequent.

Trichocolea tomentella (Ehrh.) Dum (W) Wet banks in wood near the river, very local.

Blepharostoma trichophyllum (L.) Dum. (R) On rocks and banks, usually interwoven with mosses or other hepatics, also (W) on stumps, frequent.

Lepidozia reptans (L.) Dum. (W) Damp mossy ground, rotten logs, tree-stumps, etc., common.

Calypogeia muelleriana (Schiffn.) K. Müll. (*C. trichomanis* auct. angl. plur.) (R) Moist soil on banks, occasionally, also (W) in similar places in the woods, scarce.

C. fissa (L.) Raddi (R) (W) (P) A very common species of damp soil on the ground, by ditches, on stumps, etc.

C. arguta Nees & Mont. (W) Similar habitats, rather rare.

Lophozia ventricosa (Dicks.) Dum. (R) Common on rocky banks, also (W) on the ground and on stumps.

Barbilophozia floerkei (Web. & Mohr.) Loeske (W) Moist ground, and (P) wall-tops, etc., frequent.

B. hatcheri (Evans) Loeske (R) (W) (P) Similar habitats, equally frequent, or perhaps more so.

B. barbata (Schmid.) Loeske Rocks at the Burn; A. Croall (1). Not yet refound.

Tritomaria quinquedentata (Huds.) Buch. (R) Wet rocks, rather common.

Solenostoma triste (Nees) K. Müll. (R) Common on wet rocks, often submerged.

S. atrovirens (Schl. ex Dum.) K. Müll. var. sphaerocarpoidea (De Not.) Massal. (R) Damp sandstone, frequent (5).

S. cordifolium (Hook.) Steph. (R) Submerged on rocks in river, not common.

S. crenulatum (Sm.) Mitt. (R) Wet rocks and banks, also (W) on the ground in the woods, but not common.

Plectocolea obovata (Nees) Mitt. (R) Wet rocks, frequent.

P. hyalina (Lyell ex Hook.) Mitt. (R) Wet rocks, frequent.

Nardia scalaris (Schrad.) S. F. Gray (R) (W) (P) A very common hepatic on rocks, walls and banks, also on footpaths.

Marsupella emarginata (Ehrh.) Dum. (R) Among wet rocks and stones, rather common.

Plagiochila asplenioides (L.) Dum. Rocks at the Burn; A. Croall (1). (R) Rocks and banks, very common, also (W) on the ground and on stumps, occasionally (P) on walls.

var. major Nees (R) Rocks, especially by the river just above Gannochy Bridge, (W) on the ground, and (P) sometimes on wall-tops, frequent in very damp situations.

Lophocolea bidentata (L.) Dum. (W) (P) Grassy places, lawns, etc., frequent.

L. cuspidata (Nees) Limpr. (R) (W) (P) A very common species of banks, damp tree-trunks and especially stumps, sometimes among mosses on walls.

L. HETEROPHYLLA (Schrad.) Dum. (W) Found commonly on tree stumps or rotting logs in damp places.

CHILOSCYPHUS POLYANTHOS (L.) Corda (R) Wet rocks, sometimes submerged, and (W) stones and ditch-sides, rather common.
var. RIVULARIS (Schrad.) Nees (R) Submerged on rocks in the river, also (P) on stones in the main ditch that passes through the estate.

CEPHALOZIELLA STARKEI (Funck) Schiffn. (R) Interwoven with mosses and other hepatics on rocks and banks, as well as (W) on the ground on foot-paths, stumps, etc., common.

CEPHALOZIA BICUSPIDATA (L.) Dum. (W) (P) Moist soil, for instance on foot-paths and on rotten logs, etc., common.

C. MEDIA Lindb. (R) Damp sandstone between Gannochy Bridge and Loups Bridge, not common.

NOWELLIA CURVIFOLIA (Dicks.) Mitt. (W) Rotten logs in very wet places, usually associated with *Lophocolea heterophylla* and occasionally with *Riccardia latifrons* and *R. palmata*, frequent.

DIPLOPHYLLUM ALBICANS (L.) Dum. Mud fences at the Burn; A. Croall (1). (R) (W) (P) The most abundant liverwort throughout the area, found everywhere on rocks, banks, stumps, by ditches, on footpaths, etc.

SCAPANIA CURTA (Mart.) Dum. (W) Moist soil in bare places, sometimes on turf on walls.

S. IRRIGUA (Nees) Dum. (R) Wet places among stones, occasionally.

S. GRACILIS (Lindb.) Kaal. (R) Rocky banks, rare.

S. UNDULATA (L.) Dum. (including *S. dentata* Dum.) (R) Wet rocks in, and by, the river, common.

S. SUBALPINA (Nees) Dum. (R) A common and characteristic species of wet rocks and gravelly soil all along the river's edge.

S. COMPACTA (Roth) Dum. (W) Bare stony grounds, rather rare.

RADULA COMPLANATA (L.) Dum. (R) Wet rocks by the river, occasionally, (W) more abundantly on trees and rocks in the woods.

LEJEUNEA CAVIFOLIA (Ehrh.) Lindb. (R) On mosses on damp rocks, frequent (6).

FRULLANIA TAMARISCI (L.) Dum. (R) Rocks, rather common, also (W) on banks and stumps, sometimes (P) on damp walls.

F. DILATATA (L.) Dum. (W) Trees, very common.

MOSSES.

ATRICHUM UNDULATUM (Hedw.) P. Beauv. (R) Wet stony ground, and (W) (P) on the ground, stumps, etc., common.

POLYTRICHUM ALOIDES Hedw. At the Burn; A. Croall (1). (R) (W) (P) Banks, tree-roots, turf on wall-tops, very common.

P. URNIGERUM Hedw. At the Burn; A. Croall (1). (R) (W) Common on rather stony ground, especially along the edge of the wood by the river.

P. PILIFERUM Hedw. (W) (P) A common species of turf on the ground or on wall-tops.

P. JUNIPERINUM Hedw. (W) (P) Similar habitats, common.

P. FORMOSUM Hedw. (W) (P) A very common species on the ground, roots, wall-tops, etc., throughout the woods and policies, except in open grassy situations.

P. COMMUNE Hedw. (W) Frequent in damp places on the ground in the woods.

DIPHYSCIUM FOLIOSUM (Hedw.) Mohr. (W) Common on well-drained turf on banks, especially along the edge of the wood by the river, also (P) on wall-tops where soil has lodged.

FISSIDENS MINUTULUS Sull. (*F. pusillus* Wils.) (R) Damp rocks, sometimes submerged, rather local.

F. BRYOIDES Hedw. (W) Wet banks and ditch-sides, fairly common.

F. TAXIFOLIUS Hedw. (R) Among wet rocks, and (W) on the ground in damp places in the woods, especially by ditches, considerably more common than the last.

F. CRISTATUS Wils. (R) Only noted on rocks on the river bank, where it is fairly frequent.

F ADIANTOIDES (R) Common on wet rocks and in boggy places along the river, and also (W) in rills in the wood, usually near the river.

DITRICHUM CYLINDRICUM (Hedw.) Grout (P) Locally abundant in bare spots in grass fields, especially the large field west of the mansion-house.

D. HETEROMALLUM (Hedw.) E. G. Britton (W) Banks on light or sandy soil, especially along the path by the river, also (P) in similar places about the policies, frequent.

D. FLEXICAULE (Schleich.) Hampe Rocks at the Burn; A. Croall (1). (R) Frequent on calciferous rocks especially just above Gannochy Bridge and Loups Bridge.

DISTICHIUM CAPILLACEUM (Hedw.) B. & S. (R) Locally abundant on rocky banks along the river.

CERATODON PURPUREUS (Hedw.) Brid. (R) (W) (P) On the ground and on rocks, banks, walls, paths, everywhere.

SELIGERIA RECURVATA (Hedw.) B. & S. (R) Rock by the North Esk river, at the Burn, plentiful; A. Croall (1). Still abundant in Croall's station (a large rock jutting out into the river, only accessible with difficulty when the water is high); also found, but more rarely, on rocks in the vicinity.

BLINDIA ACUTA (Hedw.) B. & S. (R) On wet rocks and in stony places, common.

DICRANELLA VARIA (Hedw.) Schp. (R) Wet river banks, rather rare.

D. HETEROMALLA (Hedw.) Schp. (R) (W) (P) A very common species of turf, tree-stumps, etc., also on turf-covered walls throughout the estate.

CYNODONTIUM JENNERI (Schp.) Stirt. (W) On the ground, especially on banks near the path along the edge of the wood by the river, frequent.

DICHODONTIUM PELLUCIDUM (Hedw.) Schp. (R) Wet rocks and stony places, common.

var. FLAVESCENS (Turn.) C. Jens. (R) Wet rocks, occasionally.

Dicranoweisia cirrata (Hedw.) Lindb. (W) Tree-trunks, rotting stumps and logs, frequent to common, also found (P) on walls.

Dicranum fuscescens Turn. (W) On the ground, common, also occasionally on trees and roots, and (P) on walls.

D. majus Turn. (W) On the ground, rather common.

D. scoparium Hedw. (R) (W) (P) Very common on the ground, rocks, walls and stumps, also on tree-trunks.

Campylopus flexuosus (Hedw.) Brid. (W) On the ground, on stumps, etc., rather common

Leucobryum glaucum (Hedw.) Schp. (W) This characteristic plant of damp beech-woods is common here too, on the ground.

Encalypta ciliata Hedw. (R) N. Esk above Gannachie Bridge (2). This record is included here in spite of there being no indication as to county (or name of collector); but the nature of the rocks on the Kincardineshire side, and the fact that other species normally found on mountain rocks, such as *Isopterygium pulchellum*, still persist here, makes it almost certain that the *Encalypta* was seen in our sector. It has, however, not been refound.

E. streptocarpa Hedw. Old walls at the Burn; A. Croall (1). Wall at N. end of Gannachie Bridge (2). The latter record is included (although here again no name of the county or the collector is given) because the north end of the bridge can hardly be disputed as lying in Kincardineshire. (R) Rocks, and (P) mortar of walls, locally abundant, especially near Gannochy Bridge.

Tortula subulata Hedw. (R) Frequent on rocky banks, and (P) on the ground and on walls.

T muralis Hedw. (R) (W) (P) On rocks, stones and especially walls, common.

Pottia truncata (Hedw.) Fürnr. (P) An abundant moss of bare soil in fields and garden ground.

Phascum cuspidatum Hedw. (P) Similar habitats, but less common.

Cinclidotus fontinaloides (Hedw.) P. Beauv. (R) Rocks in the river, normally submerged, frequent.

Barbula convoluta Hedw. (R) (W) (P) Moist rocks, walls and bare ground, especially near dwellings, on garden paths, etc., very common.

var. commutata (Jur.) Husnot (P) Seen in one place only, on a damp wall by the roadside.

B. unguiculata Hedw. (R) (P) Rocks and walls, rather common.

B. fallax Hedw. (R) Frequent all along the river, in wet rocky or stony ground near the edge.

B. spadicea Mitt. (R) Wet rocks, local.

B. rigidula (Hedw.) Mitt. (R) Rocks, and (P) walls, rather common.

B. tophacea (Brid.) Mitt. (R) Rocks, less frequent than expected, not yet noted on walls.

B. cylindrica (Tayl.) Schp. (R) Common on damp rocks, also (P) on walls and moist ground.

B. FERRUGINASCENS Stirton (R) Locally common on damp calciferous rocks, especially just above Gannochy Bridge and near Loups Bridge (4) (5).

B. RECURVIROSTRIS (Hedw.) Dix. Rocks at the Burn, parish of Fettercairn; A. Croall (1). (R) Common on rocks, and (W) in wet stony places, above all (P) on walls.

GYMNOSTOMUM AERUGINOSUM Sm. At the Burn; A. Croall (1). (R) Wet rocks, rather common.

G RECURVIROSTRUM Hedw. (R) Similar habitats, less frequent.

GYROWEISSIA TENUIS (Hedw.) Schp. North Esk, at the Burn, abundant; A. Croall (1). (R) Damp rocks, especially near Gannochy Bridge and extending as far as Loups Bridge, very common, also (P) on walls, mainly on the Edzell road.

EUCLADIUM VERTICILLATUM (With.) B. & S. (R) Damp rocks, frequent.

ANOECTANGIUM COMPACTUM Schwaegr. (R) Similar habitats, not common (5).

TORTELLA TORTUOSA (Hedw.) Limpr. Rocks at the Burn; A. Croall (1). (R) Calciferous rocks, mainly just above Gannochy Bridge and at Loups Bridge, locally common.

TRICHOSTOMUM BRACHYDONTIUM Bruch (R) Soil-covered rocks, and (W) banks in the wood along the river, not common.

WEISSIA CONTROVERSA Hedw. (R) (W) (P) A common species of shady banks, interstices of walls, etc.

W. MICROSTOMA (Hedw.) C.M. (R) Only seen on calciferous rocks just above Gannochy Bridge, no doubt also present in similar habitats elsewhere along the river banks.

GRIMMIA APOCARPA Hedw. (R) (W) (P) An abundant species of rocks and walls.

G. ALPICOLA Hedw. (R) Common on rocks and boulders, usually near the water's edge.
var. RIVULARIS (Brid.) Broth. (R) Submerged on rocks, rather common.

G. PULVINATA (Hedw.) Sm. (R) (W) (P) A very common moss of rocks and walls.

G. TRICHOPHYLLA Grev. (R) Rocks, and (W) stones on the ground, also (P) walls, especially near Gannochy Bridge, frequent.

RHACOMITRIUM ACICULARE (Hedw.) Brid. Rocks at the Burn; A. Croall (1). (R) An abundant moss of rocks in, and by, the river, also seen (W) on the boles and lowest branches of trees overhanging the water.

R. FASCICULARE (Hedw.) Brid. (P) Only seen in a few places on walls and stones on the ground in the policies.

R. HETEROSTICHUM (Hedw.) Brid. (R) (W) (P) Very common on rocks and walls, usually in rather dry places.

FUNARIA HYGROMETRICA Hedw. (W) (P) Common on moist soil, burnt ground, etc.

EPHEMERUM SERRATUM var. MINUTISSIMUM (Lindb.) Grout (P) Bare moist soil in the fields, garden ground, etc., but easily overlooked.

TETRAPHIS PELLUCIDA Hedw. (R) (W) Rocky banks and stumps at the edge of the wood on the river bank, rather rare.

Pohlia cruda Hedw. (R) Damp rocks, fairly frequent.

P. nutans (Hedw.) Lindb. (R) (W) (P) A very common species of turf, tree-roots and bare ground throughout.

P. albicans (Wahl.) Lindb. (R) Wet places, not common.

Anomobryum filiforme (Dicks.) Husn. (R) Common in wet stony ground or on damp rocks all along the river.

Bryum inclinatum (Brid.) Bland. (R) Rocky banks, frequent.

B. pallens (Brid.) Röhl. (R) Common in wet ground by the river.

B. pseudotriquetrum (Hedw.) Schwaegr. (R) Damp rocks and wet stony ground, rather common.

var. bimum (Brid.) Richards & Wallace Rocks at the Burn; A. Croall (1). Not yet refound, but a specimen of *Bryum*, collected on rocks by the river in 1957 (and again in 1959), was det. *B. bimum* × *cernuum*, with a query, by Dr. Elsa Nyholm, the Swedish bryologist.

B. argenteum Hedw. (W) (P) Frequent on soil or gravel, especially near houses, by roadsides, and in similar places.

B. bicolor Dicks. (R) (W) (P) More common than the preceding species on moist fallow ground, chiefly in fields and garden ground, also by roadsides and drives.

B. capillare Hedw. (R) (W) (P) Moist soil, rocky banks, walls, tree-roots, very common.

Rhodobryum roseum (Hedw.) Limpr. (W) Woods of the Burn; A. Croall (1). Still there, but in very small quantity, on banks near the river.

Mnium hornum Hedw. (R) (W) (P) An abundant species, especially found on the ground under beech, also on rocks and walls.

M. marginatum (With.) Brid. ex P. Beauv. (R) Damp rocks, uncommon.

M. stellare Hedw. (R) Similar habitats, rare.

M. longirostrum Brid. (R) Stony river banks, and (W) similar ground in the woods, rather common.

M. undulatum Hedw. (R) Rocky banks, and (W) on the ground throughout the woods, common.

M. punctatum Hedw. (R) (W) (P) Similar habitats, but in wetter ground, common.

Aulacomnium palustre (Hedw.) Schwaegr. (R) Wet ground, local.

Bartramia pomiformis Hedw. Rocks at the Burn; A. Croall (1). (R) Rather common by the river on rocks, also (P) on walls.

B. ithyphylla Brid. (R) (P) Similar habitats, but even more common.

Philonotis fontana (Hedw.) Brid. (R) Common in wet places along the river, also (P) sometimes found on damp paths.

P. calcarea (B. & S.) Schp. Rocks at the Burn; A. Croall (1). (R) Calcareous flushes, local.

Breutelia chrysocoma (Dicks.) Lindb. Rocks at the Burn; A. Croall (1). Never re-found, at least to my knowledge.

Amphidium mougeotii (B. & S.) Schp. (R) Wet rocks, common.

Zygodon viridissimus (Dicks.) R.Br. (*Z. viridissimus* var. *occidentalis* (Correns) Malta) (W) Common, mainly on trees.
var. stirtoni (Schp. ex Stirt.) Hagen (R) (W) (P) Equally common, or perhaps more so, generally on rocks and walls.

Orthotrichum anomalum Hedw. (incl. *O. anomalum* var. *saxatile* (Wood) Milde) (P) Walls, very local.

O. affine Brid. (W) On trees, very common, occasionally found (P) on walls.

O. striatum Hedw. (W) On trees, with a preference for ash and wych elm, rather rare.

O. lyellii Hook. & Tayl. (W) Common on trees.

O. rivulare Turn. (R) On rocks in the river, and (W) on stones in a small stream near its junction with the river, local.

O. stramineum Hornsch. (W) On trees, rather common.

O pulchellum Brunton The apparent absence of this species is very remarkable.

O. diaphanum (R) (W) (P) A common species of trees, and occasionally of rocks and walls.

Ulota crispa (Hedw.) Brid. At the Burn; A. Croall (1). (W) Trees, rather scarce, and only noted near the river in the northern part of our area.

U. bruchii Hornsch. At the Burn, parish of Fettercairn; A. Croall (1). (W) Trees, very common, especially near the river.

U. americana (P. Beauv.) Limpr. Rocks at the Burn; A. Croall (as *Orthotrichum hutchinsiae* Smith) (1). This species has been searched for in vain, but may still be re-found.

Fontinalis antipyretica Hedw. (R) Rocks, normally submerged, common, also (W) on stones in ditches in the woods, and (P) at the foot of a wall by water.

F. squamosa Hedw. (R) Submerged on rocks, common.

Climacium dendroides (Hedw.) Web. & Mohr (R) Wet stony ground, frequent, occasionally (W) in damp ground by ditches.

Hedwigia ciliata (Hedw.) P. Beauv. (R) (W) (P) Rather common on rocks and stones throughout.

Pterogonium gracile (Hedw.) Sm. (R) Rocky banks in wood near the river, rather rare.

Homalia trichomanoides (Hedw.) B. & S. (W) Moist rocky banks and tree-stumps, occasionally.

Thamnium alopecurum (Hedw.) B. & S. (R) Common on wet rocks, sometimes submerged.

Hookeria lucens (Hedw.) Sm. (R) Wet rocks, and (W) in flushes in the woods near the river, frequent.

Thuidium tamarascinum (Hedw.) B. & S. (R) (W) (P) On turf throughout, especially on the ground under trees.

T delicatulum (Hedw.) Mitt. (R) Only seen on calcareous stony ground near Loups Bridge (4) (6).

Cratoneuron filicinum (Hedw.) Roth. Rocks at the Burn; A. Croall (1) (R) Wet rocks all along the river, common, also (W) in wet ground by ditches in woods, occasionally.

C. commutatum (Hedw.) Roth. (R) Wet rocks, locally abundant.

Campylium stellatum (Hedw.) Lange & C. Jens. (R) Wet flushes among rocks, frequent.

C.protensum (Brid.) Kindb. (R) Wet calciferous rocks, also frequent (4) (5).

Hygroamblystegium fluviatile (Hedw.) Loeske (R) Submerged on rocks, rather common (5).

Amblystegium serpens (Hedw.) B. & S. (W) Woods of the Burn; A. Croall (1). Abundant on the ground, on stones, tree-roots, etc., also (P) throughout the policies.

Drepanocladus uncinatus (Hedw.) Warnst. (R) (W) (P) Rather common on rocky banks, walls, etc.

Hygrohypnum ochraceum (Turn. ex Wils.) Loeske (R) Rocks, normally submerged, common.

H. luridum (Hedw.) Jennings Rocks at the Burn; A. Croall (1). (R) Similar habitats, very common.

H. eugyrium (B. & S.) Loeske (R) Rocks in, and by, the river, frequent.

H. dilatatum (Wils.) Loeske (R) Seen at low water covering a single boulder, usually submerged; probably more frequent (4).

Acrocladium cuspidatum (Hedw.) Lindb. (R) Wet ground, abundant, also (W) in similar places in the woods.

Isothecium myurum (Brid.) Brid. (W) Banks, tree-roots, frequent.

I. myosuroides Brid. (R) (W) (P) Similar habitats, abundant.

Camptothecium sericeum (Hedw.) Kindb. (R) (W) (P) Rather common on rocks and walls.

Brachythecium albicans (Hedw.) B. & S. (P) In quantity in the walled garden, in stony and gravelly places, perhaps at one time introduced; also occasionally in similar places near by.

B. glareosum (Bruch) B. & S. (R) Damp rocks, rather rare (4).

B. rutabulum (Hedw.) B. & S. (R) (W) (P) An abundant species of rocks, walls, tree-roots and soil throughout.

B. rivulare (Bruch) B. & S. Rocks at the Burn; A. Croall (1). (R) Rocks along the river margin, often submerged, common.

B. velutinum (Hedw.) B. & S. (R) Rocky banks, (W) Woods of the Burn; A. Croall (1). On the ground, tree-roots, and (P) on walls, common.

B. populeum (Hedw.) B. & S. (R) (W) (P) Similar places, frequent.

B. plumosum (Hedw.) B. & S. (R) Rocks, often submerged, very common.

Cirriphyllum crassinervium (Tayl.) Loeske & Fleisch. (R) Rocky banks, occasionally, also (W) in the wood near the river.

Eurynchium striatum (Hedw.) Schp. emend. Störmer (R) Rocky banks. (W) Woods of the Burn; A. Croall (1). Common on the ground everywhere in the woods where there is stiff soil.

E. praelongum (Hedw.) Hobk. (R) (W) (P) Very common on every sort of substratum.
var. stokesii (Turn.) Hobk. (R) Rocky banks near the river's edge, frequent.

E. swartzii (Turn.) Curn. (P) On the ground in bare places in fields, rather common.

E. RIPARIOIDES (Hedw.) Jennings Rocks of the Burn; A. Croall (1). (R) Very common on rocks in, and by, the river, also (W) on stones and roots by ditches.

E. ALOPECURUM (Brid.) Richards & Wallace (R) Rocks in the river, rather rare.

E. CONFERTUM (Dicks.) Milde (R) (W) Stony ground, tree-stumps, etc., frequent.

RHYNCOSTEGIELLA TENELLA (Dicks) Limpr. (R) Rocks, and (P) walls, frequent in damp places, especially near Gannochy Bridge.

PSEUDOSCLEROPODIUM PURUM (Hedw.) Fleisch. (W) (P) Very common on turf, especially in damp shady places.

PLEUROZIUM SCHREBERI (Brid.) Mitt. (W) (P) Equally common in similar habitats.

ISOPTERYGIUM PULCHELLUM (Hedw.) Jaeg. & Sauerb. (R) Moist calciferous rocks, where it is frequent.

I. ELEGANS (Hook.) Lindb. (R) (W) (P) A common species of turf throughout, also on tree-stumps and wall-tops.

PLAGIOTHECIUM DENTICULATUM (Hedw.) B. & S. (W) Woods of the Burn; A. Croall (1). On the ground in shady places, and also on tree-stumps, common.

P. UNDULATUM (Hedw.) B. & S. (W) Moist ground in woods, locally common.

HYPNUM CUPRESSIFORME Hedw. (R) (W) (P) On every sort of substratum; ubiquetous.

var. FILIFORME Brid. (W) Common, chiefly on beech-trunks.

var. ERICETORUM B. & S. (W) Locally abundant on the ground, especially among heather.

var. TECTORUM Brid. (R) (W) (P) A common variety of stony ground and especially of walls.

CTENIDIUM MOLLUSCUM (Hedw.) Mitt. (R) Common on calcareous rocks, in damp places by the river, above all near Gannochy Bridge and Loups Bridge.

var. CONDENSATUM (Schp.) Braithw. (R) Seen in a single locality by Loups Bridge (5).

RHYTIDIADELPHUS TRIQUETRUS (Hedw.) Warnst. (W) On the ground in shady places, also (P) on turf on wall-tops, very common.

R. SQUARROSUS (Hedw.) Warnst. (W) Woods of the Burn; A. Croall (1). Abundant on the ground in woods, as well as (P) in grassy places throughout the policies, except in fields where trampled by cattle.

R. LOREUS (Hedw.) Warnst. (W) On the ground, usually under trees, common.

HYLOCOMIUM SPLENDENS (Hedw.) B. & S. (W) (P) On the ground in woods, etc., in similar places to *Pseudoscleropodium* and *Pleurozium*, very common.

LICHENS.

USNEA HIRTA (L.) Wigg. emend. Mot. (W) Trees, mainly conifers, also (P) on fence-posts, rather rare.

U. DASYPOGA (Ach.) Röhl emend. Mot. (W) Trees, especially beech, not common (3).

U. COMOSA (Ach.) Röhl. (W) Very common on trees, also seen (P) on fence-posts.

U. MOLLIS Stirt. (W) On beech, rather local (3).

ALECTORIA JUBATA (L.) Ach. (W) Common on trees, also occurring (P) on fences.

var. SUBCANA Nyl. (W) Trees, especially oak and beech, local (3).

A. IMPLEXA (Hoffm.) Nyl. (W) Only seen on beech, local (3).

EVERNIA PRUNASTRI (L.) Ach. (W) Trees, very common, also seen (P) on fence-posts.

E. FURFURACEA (L.) Ach. (W) Trees, less common than the last species, but found throughout, also (P) sometimes on fences.

PARMELIA TRICHOTERA Hue (W) Rather common on trees, chiefly on beech.

P. CAPERATA (L.) Ach. (W) Frequent on various kinds of deciduous trees, but mainly on beech.

P. SUBAURIFERA Nyl. (W) A very common species of trees throughout, also found (P) on fences.

P. FULIGINOSA Nyl. (R) (W) (P) Rocks, walls, occasionally on fences, common.

var. LAETEVIRENS (Flot.) Kichz. (W) Trees, very common, sometimes (P) on fences.

P. CONSPERSA (Ehrh.) Ach. (R) Rocks, frequent.

var. STENOPHYLLA Ach. (R) Similar habitats, also frequent.

P. MOUGEOTII Schaer. (R) Rocks near Loups Bridge, also (P) on schistose stones on the ground, occasionally.

P. SAXATILIS (L.) Ach. (R) (W) (P) An abundant species of rocks, walls and trees, especially in damp places.

P. SULCATA Tayl. (W) (P) Trees, sometimes on fences and walls, very common, but less so than the last species and preferring more airy places.

HYPOGYMNIA PHYSODES (L.) Wats. (R) (W) (P) Perhaps the most abundant lichen, found on every sort of substratum.

var. PLATYPHYLLA (Ach.) Wats. (W) (P) Occasionally on trees, mainly conifers, but seen at its best development on fence posts.

H. TUBULOSA (Schaer.) Räs. (W) Trees, frequent.

PARMELIOPSIS AMBIGUA (Wulf.) Nyl. (R) Trees, especially conifers, and stumps, frequent. (3).

PLATYSMA GLAUCUM (L.) Nyl. (R) (W) (P) A very common species of trees, fences, walls, sometimes found on the ground.

var. FALLAX (Web.) Nyl. (W) Seen occasionally on trees.

P. CHLOROPHYLLUM (Humb.) Wats. (W) On conifers, especially larch, also (P) on fence posts, frequent.

CETRARIA ACULEATA (Schreb.) Fr. (R) Rocks by Loups Bridge, etc., rather local.

SQUAMARIA MURALIS (Schreb.) Elenk. (R) On rocks, rather common, also (P) on stones and walls.

Lecanora dispersa (Pers.) Röhl. (incl. *L. galactina* Ach. and *L. hageni* Ach.) (R) (W) (P) A very common lichen of rocks and walls, both as the f. *dispersa* and as the f. *albescens*, sometimes (*L. hageni*) on trees and fence-posts.

L. subfuscata Magn. (W) Trees, not common.

L. allophana (Ach.) Rohl. (W) Trees, especially ash and sycamore, not common.

L. chlarona (Ach.) Cromb. (W) Trees, especially beech, alder, etc., very common, also (P) on fence-posts and gates.
var. pinastre (Schaer.) (W) Frequent on larch and pine, also occurring (P) on fences.

L. chlarotera Nyl. (W) (P) Common as the f. *rugosella* on trees and fence-posts, the f. *crassula* more rare, and usually found in damper places, such as on alder by the river.

L. campestris (Schaer.) Hue (incl. *L. coilocarpa* (Ach.) Nyl.) (R) (P) Rocks and walls, common.

L. pallida (Schreb.) Schaer. (W) Trees, especially beech, not common.

L. carpinea (L) Wain. (W) Trees, and (P) fence-posts, rather scarce.

L. sordida (Pers.) Ach. (R) (P) Rocks and especially walls, fairly common.

L. atra (Huds.) Ach. (R) (P) Similar habitats, common.

L. polytropa (Ehrh.) Schaer. (R) (W) (P) Rocks, stones in the woods, also on walls, rather common.

L. intricata Ach. (R) (W) (P) Similar habitats, also rather common.

L. expallens (Pers.) Ach. (W) An abundant species of trees and (P) fences.

L. conizaeoides Cromb. (W) Rather common on trees, birch, pine, etc., also (P) found on fences.

L. symmicta Ach. (W) On trees, especially larch, and (P) fence-posts. (The var. symmictera (Nyl.) A. Zahlbr. not yet noted.)

Ochrolechia androgyna (Hoffm.) Arn. (*O. tartarea* var. *subtartarea* (Massal.)) (R) (W) (P) A common species of rocks, walls, trees, and stumps.

O. parella (L) Massal. (R) (W) (P) Rocks, walls, and sometimes trees, very common.

Aspicilia calcarea (L.) Krb. (R) Rocks, and (P) walls, frequent.
var. contorta (Hoffm.) Mudd (R) (P) Similar habitats, frequent.

A. lacustris (With.) Th. Fr. (R) Rocks in the river, normally submerged, common.

Psora ostreata Hoffm. (W) On the boles of conifers, frequent.

Biatora lucida (Ach.) Fr. A yellow thallus occurs on rocks and walls which may belong to this species, but it cannot safely be named in the absence of apothecia.

B. coarctata (Sm.) Th. Fr. (R) (W) (P) On rocks and stones, frequent.
var. glebulosa (Sm.) Arn. (R) (W) (P) Similar habitats, occasionally.

B. granulosa (Ehrh.) Lindb. (R) (W) Very common on damp banks, turf on wall-tops, and especially on roots or rotting logs.

B. uliginosa (Schrad.) Fr. (W) On damp peaty soil, also turf on decaying roots, frequent.

Lecidea enterochlora Tayl. (*L. protrusa* Schaer.) (R) (W) (P) A very common lichen of rocks, stones and walls.

L. parasema Ach. (W) Trees, and (P) fences, common.
var. elaeochroma Ach. (W) Rather common on trees in damp situations along the river.

L. goniophila (Flörke) Schaer. (R) (W) (P) Rocks and stones, rather common.

L. leucophaea (Flörke) Nyl. (W) Only seen on schistose stones on the ground in an open part of the wood, probably also on walls.

L. pantherina (Ach.) Th. Fr. (R) Rocks, especially near Loups Bridge, locally abundant.

L. lithophila Ach. (P) Walls, not common.

L. macrocarpa (DC.) Steüd. (*L. contigua* (Hoffm.) Th. Fr.) (R) (W) (P) Rocks, stones and walls, very common.

L. tumida Massal. (R) Similar habitats, also common.

L. albocoerulescens (Wulf.) Ach. (R) (W) (P) Similar habitats, widespread.

L. confluens (Web.) Ach. (R) (W) (P) Another saxicolous lichen; frequent.

L. cinerascens (With.) A. L. Sm. (R) Rocks, especially along the river, common.

L. fuscoatra (L.) Ach. (W) Seen on schistose stones on the ground in an open part of the wood, probably also to be found elsewhere.

Pertusaria lactea (L.) Nyl. (R) Rocks along the river, frequent.

P. amara (Ach.) Nyl. (W) On trees, especially beech, very common.

P. pertusa (L.) Tuck. (W) Very common on trees, the f. rupestris seen (R) on rocks by the river.

P. corallina (L.) Fr. (R) Rather common on rocks, also (P) on walls.

P. leioplaca (Ach.) Schaer. (W) Trees, common.

P. wulfenii DC. (W) Trees, rather common.

P. globulifera (Turn.) Massal. (W) Trees, fairly frequent.
var. discoidea (Pers.) Almb. (W) Rather more common on trees.
var. corallina A. Zahlbr. (*P. henrici* (Harm.) Erichs.) Trees, frequent.

Acarospora fuscata (Schreb.) (R) (W) (P) Rather common wherever there are rocks and stones.

Biatorella pruinosa (Sm.) Mudd (R) Calciferous rocks, especially by Loups Bridge, and (P) common on mortar of walls.

Ramalina calicaris (L.) Fr. (W) Trees, frequent.

R. farinacea (L.) Ach. (W) Trees, very common.

R. fraxinea (L.) Ach. (W) Seen occasionally, for instance on trees in the fields.

R. fastigiata (Pers.) Ach. (W) Trees, rather common.

Biatorina griffithii (Sm.) Massal. (W) Trees, rather common, especially on conifers.

B. lenticularis (Ach.) Krb. (R) (W) (P) Frequent on rocks and stones.

'ATILLARIA CHALYBEIA (Borr.) Massal. (R) Similar habitats, especially along the river, sometimes submerged.

C. PREMNEA (Fr.) Krb. (W) On trees, with a preference for ash, rather rare.

BILIMBIA SABULETORUM (Florke) Arn. (P) On dead mosses on wall, rare or overlooked.

XANTHORIA PARIETINA (L.) Th. Fr. (R) Rocks, and (W) trees, especially in the fields, and (P) also sometimes on walls, frequent.

X. POLYCARPA (Ehrh.) Oliv. (W) Trees, rather rare.

X. LYCHNEA (Ach.) Th. Fr. (W) Trees in the fields, rather scarce.

CALOPLACA PUSILLA (Massal.) A. Zahlbr. (P) Walls, local.

C. CITRINA (Hoffm.) Th. Fr. (P) A very common species of walls.

C. AURANTIACA (Lightf.) Th. Fr. var. FLAVOVIRESCENS (Wulf.) Mig. (R) Rocks by the river, very local.

C. PYRACEA (Ach.) Th. Fr. (R) Calciferous rocks, and (P) mortar of walls, frequent.

C. FERRUGINEA (Huds.) Th. Fr. var. FESTIVA (Ach.) Th. Fr. (R) Rocks, and (P) walls, not common.

PROTOBLASTENIA RUPESTRIS (Scop.) A. Zahlbr. (R) Calciferous rocks, and (P) cement of walls, frequent.

CANDELARIELLA VITELLINA (Ehrh.) Müll. Arg. (R) (W) (P) Rocks and walls, very common, also rarely (W) on trees in the fields.

ANAPTYCHIA CILIARIS (L.) Massal. (W) Trees, especially ash, very local (3).

PHYSCIA PULVERULENTA (Schreb.) Nyl. (W) Old trees, especially in the fields, frequent.

P. GRISEA (Lamarck) A. Zahlbr. (W) Similar habitats, also frequent, perhaps rather more so.

P. TENELLA (Scop.) DC. (R) (W) (P) Rocks, walls and trees, common.

P. ADSCENDENS (Th. Fr.) Oliv. (W) Trees, rather local (3).

P. STELLARIS (L.) Nyl. (W) Trees, rather rare.

P. CAESIA (Hoffm.) Nyl. (R) Boulders along the river, (W) stones on the ground, and (P) on walls, paving-stones, etc., common.

P VIRELLA (Ach.) Lynge (incl. *P. orbicularis* (Neck.) Poetsch.) (R) Rocks, (W) old trees, especially in the fields, rather common, sometimes (P) on walls.

RINODINA EXIGUA (Ach.) S. F. Gray (W) Trees, occasionally.

R. DEMISSA (Krb.) Arn. (R) (P) Rocks and walls, frequent.

BUELLIA MYRIOCARPA (DC.) de Not. (W) Old trees, not common.

B. DISCIFORMIS (Fr.) Mudd (W) Trees, especially beech, infrequent.

RHIZOCARPON ALBOATRUM (Hoffm.) Th. Fr. var. EPIPOLIUM (Ach.) A. L. Sm. (P) Walls, frequent.

R. GEOGRAPHICUM (L.) DC. (agg.) (R) Rocks, common, especially along the river, and (P) occasionally on walls.

R PETRAEUM (Wulf.) Massal. (R) (W) (P) Rather common on rocks and walls throughout.

R. GRANDE (Flörke) Arn. (R) (W) (P) Rocks and walls, chiefly schistose, frequent. (The only member of the *confervoides* group seen.)

R. OBSCURATUM (Ach.) Massal. (R) (W) (P) A common saxicolous lichen, found on rocks and walls, especially by the river, often submerged.

DIPLOSCHISTES SCRUPOSUS (L.) Norm. (R) Damp rocks, and (P) walls, frequent.

PHLYCTIS ARGENA (Ach.) Krb. (W) Only one of the two species of *Phlyctis* occurs on trees, where it is common, but in the absence of fruit it is not possible to assign it with any certainty to either. From vegetative characters it appears to be *P. argena*.

CLADONIA TENUIS (Flörke) Harm. (W) On the ground in open parts of the wood, fairly frequent.

C. IMPEXA Harm. (W) Similar habitats, common.

C PYXIDATA (L.) Hoffm. (R) (W) (P) A fairly common species of rather dry ground, tree-roots, walls, etc.

C. POCILLUM (Ach.) Rich. (R) (P) Common on calciferous rocks and walls, especially along the river.

C. CHLOROPHAEA (Flk.) Spreng. (R) (W) (P) A common species of damp rocks and walls, etc. (Many plants are now placed here which would formerly have been named *C. pyxidata*.)

C. FIMBRIATA (L.) Fr. (R) (W) (P) Another common species, preferring rather lighter, drier soil than the last. Chiefly found on banks, tree-roots and walls.

C. CORNUTORADIATA (Coem.) Sands. (incl. *C. fimbriata* var. *subulata* (L.) Wain.) (R) (W) (P) Similar habitats, very common.

C. CONIOCRAEA (Flk.) Wain. (R) (W) (P) Banks and tree-stumps, frequent.

C. PITYREA (Flk.) Fr. (W) On the ground, rather rare.

C. CERVICORNIS (Ach.) Schaer. (R) Mossy rocks, chiefly seen by the river, also (W) on the ground occasionally in the woods.

C. SUBCERVICORNIS Wain. (R) (W) Rocks, and on the ground, more common than the last, especially found along the river.

C. GRACILIS (L.) Willd. (R) Only seen on rocks by the river, chiefly near Loups Bridge, not at all common.

C. CRISPATA (Ach.) Flot. (W) (P) On the ground in open situations, rather rare.

C FURCATA (Huds.) Schrad. (R) (W) (P) An abundant species of turf throughout.

var. PINNATA (Flörke) Wain. (W) Frequent, especially in damp places in the woods.

C. RANGIFORMIS Hoffm. (R) Mossy calciferous rocks, especially along the river margin, frequent.

var. FOLIOSA (Flörke) Wain. (R) Only once seen on a rocky calcareous bank near Gannochy Bridge (3).

C SUBSQUAMOSA Nyl. (W) On the ground or on tree-stumps, frequent.

C. SQUAMOSA (Scop.) Hoffm. (W) Similar habitats, very common.

var. PHYLLOCOMA Rabenh. (W) Rocky banks or tree-roots, especially along the edge of the wood by the river, frequent.

C. COCCIFERA (L.) Willd. (R) Mossy rocks, occasionally, and (W) peaty soil and stumps, rather common.

C. PLEUROTA (Flk.) Schaer. (W) Similar habitats, rather local.

deformis (L.) Hoffm. (W) Peaty soil or stumps, rather rare.
C. macilenta Hoffm. (W) Similar habitats, rather common.
C. polydactyla Flörke (R) (W) (P) The commonest of the red-fruited group, found throughout on mossy rocks, peaty soil, tree-stumps, tree-boles and wall-tops. The f. *scabriuscula* is also common.
C. floerkeana (Fr.) Sommerf. (W) Rather common on the ground or on stumps in open parts of the wood.

Baeomyces rufus (Huds.) DC. (R) (W) (P) A very common species of damp rocks, walls, banks and stumps.
var. subsquamulosus Nyl. (W) Frequent along the edge of the wood by the river, probably also elsewhere.
B. placophyllus Ach. (R) Calcareous rocks by Loups Bridge, rare.
B. roseus Pers. (W) Turfy banks, frequent.

Stereocaulon coralloides Fr. (R) Mossy rocks, rather scarce.

Gyalecta cupularis (Ehrh.) Schaer. (P) Plentiful on a damp wall by the Glen Esk road, perhaps overlooked elsewhere (3).

Coenogonium ebenum (Dill.) A. L. Sm. (R) (W) (P) Locally common on damp shady rocks and walls, mainly along the river.

Lepraria membranacea (Dicks.) Lett. (*Crocynia membranacea* (Dicks.) A. Zahlbr.) (R) Damp calcareous rocks, frequent.
L. aeruginosa (Weis.) Sm. (R) (W) (P) Very common on damp rocks and walls throughout.
L. candelaris (L.) Fr. (W) Old trees, locally common.

Peltigera canina (L.) Willd. (R) (W) (P) Mossy rocks and soil, very common.
P. rufescens (Weis.) Hoffm. (R) Damp mossy rocks, rather rare.
var. praetextata (Flörke) Nyl. (R) Common on mossy rocks and banks along the river, also (W) on turf, (P) wall-tops, etc.
P. polydactyla (Neck.) Hoffm. (R) (W) (P) A very common species of turf throughout.
P. horizontalis (L.) Hoffm. (R) Mossy rocks along the river, frequent.

Peltidea aphthosa (L.) Ach. (R) Calcareous rocky banks, especially just above Gannochy Bridge and at Loups Bridge, rather common locally.
P. venosa (L.) Ach. (R) Similar habitats, rare.

Psoroma hypnorum (Dicks.) S. F. Gray (R) On mosses on rocks, rare.

Pannaria pezizoides (Web.) Leight. (R) Similar habitats, more frequent.

Placynthium nigrum (Huds.) S. F. Gray (R) Calciferous rocks, and (P) mortar of walls, frequent.

Leptogium sinuatum (Huds.) Massal. (R) Mossy rocks, rather rare.
L. lichenoides (L.) A. Zahlbr. (R) (W) (P) Among mosses on rocks, walls and trees, rather common, the f. *fimbriatum* a frequent form.

Collema tenax (Sm.) Ach. var. vulgare (Schaer.) Degel. (*C. pulposum* (Bernh.) Ach.) (R) Damp soil among rocks, frequent.
C. cristatum (L.) G. H. Web. var. marginale (Huds.) Degel. subform papulosum (Ach.) Degel. (*C. granuliferum* Nyl.) (R) Among mosses on rocky banks, rare.

C. FLACCIDUM (Ach.) Ach. (R) Wet rocks along the river, common
ARTHONIA RADIATA (Pers.) Ach. (W) Trees, frequent.
var. SWARTZIANA (Ach.) Sydow (W) Trees, very common.
A. PUNCTIFORMIS Ach. (W) Only seen on alders by the river, ra
var. MELANTERA (Ach.) Leight. (W) Similar habitats, rare.
OPEGRAPHA HERPETICA Ach. (W) Trees, not uncommon.
O. ATRA Pers. (W) Trees, common.
O. BETULINA Sm. (W) Noted on old trees in the fields, rather sca
or overlooked.
O. VULGATA Ach. (W) Similar habitats, also rather scarce.
GRAPHIS SCRIPTA (L.) Ach. (W) Common on trees throughout.
var. SERPENTINA (Ach.) Nyl. (W) Similar habitats, frequent.
GRAPHINA ANGUINA (Mont.) Müll. Arg. (W) Trees, frequent.
CHAENOTHECA MELANOPHAEA (Ach.) Zwack. (W) Old trees, mainly
the fields, on conifers.
CALICIUM VIRIDE Pers. (*C. hyperellum* Ach.) (W) Trees, rather co
mon, especially on larch and oak.
C. CURTUM Turn. & Borr. (W) Dead stumps, local (3).
STENOCYBE BYSSACEA (Fr.) Nyl. (W) On alders overhanging the riv
frequent locally.
CONIOCYBE FURFURACEA (L.) Ach. (R) (W) (P) Damp rocks and wal
tree-roots, etc., common.
DERMATOCARPON AQUATICUM (Weiss) A. Zahlbr. (R) Rocks in the riv
usually submerged, rather common.
VERRUCARIA AETHIOBOLA Wahlenb. (R) Rocks in, or by, the river, oft
submerged, frequent.
var. SUBMERSA (Schaer.) Wats. (R) Similar habitats, also s
(P) on damp walls by ditches, frequent.
V. NIGRESCENS Pers. (R) (W) (P) Common on calciferous rocks a
walls.
V. MURALIS Ach. (P) Mortar of walls, occasionally.
STAUROTHELE FISSA (Tayl.) Wain. (R) Boulders in the river, oft
submerged, local (3).
ACROCARPA BIFORMIS (Borr.) Oliv. (W) Trees, occasionally.
ARTHOPYRENIA PUNCTIFORMIS (Pers.) Arn. (W) Trees, frequent.
A. FALLAX (Nyl.) Arn. (W) Trees, also frequent.
PORINA CARPINEA (Pers.) A. Zahlbr. (W) Trees, especially bee
locally common.
P. CHLOROTICA (Ach.) Müll. Arg. (R) Rocks in, and by, the riv
frequent.
MELANOTHECA GELATINOSA (Chev.) Nyl. (W) Trees, especially rowa
along the river bank, rather rare.

Further Observations on the Bryophyte Flora of the Isle of May.

II. Rate of Succession in Selected Communities Involving Bryophytes.

E. V. Watson
(Department of Botany, University of Reading).

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Introduction.

The purpose of this communication is to present the results of studies that have been made over the period 1955-1959 on certain chosen areas on the Isle of May. There were five of these originally and a sixth was added at a later date. The areas were chosen with care in order to include a diversity of habitats and so that they might thus provide the basis for the investigation of several kinds of community. The kinds of question that I set out to answer were: (1) How long do bryophyte communities persist with little apparent change? (2) How far, in selected instances, do bryophyte colonists pave the way for flowering plant successors? (3) If there are stages representing initiation, maturity and senescence in these communities, at what rates are these stages passed through, and what changes accompany them? It is true that answers to this kind of question have been provided for certain types of bryophyte community by various authors (Doignon (1949), Fritsch and Salisbury (1915), Leach (1930), Olsen (1917), and others), but it is less easy to trace any account of the rather specialised coastal communities that prevail in such a situation as the Isle of May.

The method employed was to set up, in each of the chosen areas, a permanent 20-cm. quadrat and to return to make a chart of its vegetation at reasonably frequent intervals. The initial setting up of the quadrats was in September 1955 and they were mapped then, and again in May 1956, April 1958 and September 1959. In spring and early summer 1957 several observers (whose work is duly acknowledged later) helped by sending me information and preparing charts at a time when I was not free to visit the island myself. It is thought that the chart quadrat method presents certain decided advantages for a study of this kind.

A great deal of fairly precise information can be recorded with considerable clarity, provided suitable symbols are chosen.

Although embarked upon as a study of bryophyte communities and presented now as a "follow-up" of my earlier papers (Watson, 1953, 1957) on the bryophytes of the Isle of May, this has inevitably become at the same time an excursion into Angiosperm ecology. The significance of the bryophytes can be appreciated only in the wider context of their relationship with higher plants, and inevitably the changes traced in the marked squares are changes involving all elements in the vegetation. So Angiosperms and lower plants alike receive attention in the account that follows. In some instances the picture is one of a community passing from a phase where bryophytes are prominent to one where higher plants attain, and in all likelihood, retain supremacy.

A general account of the chief types of bryophyte community on the Isle of May was presented in an earlier paper (Watson 1953) but no report was then made on the relative acidity of the different sites. This has not been studied in detail, but in order to gain a picture of the varying conditions prevailing in different parts of the island, and with particular reference to the areas selected for special study, some records of pH were made in September 1955. Determinations were made colorimetrically using standard B.D.H. Universal indicator. It was possible to recognise in a general way 4 stages of decreasing acidity, as follows: (1) Thin soil, at the edge of rock outcrops on the north plateau, the habitat of *Polytrichum piliferum*—pH 5. (2) The sites of sea-bird colonies, near the north Horn, where *Rumex acetosa* grew in abundance, and bryophytes were absent except for an occasional plant of depauperate *Eurhynchium praelongum*—pH 5·5 or slightly above. The same approximate figure held for the dried-out pool on the south plateau (quadrat 3). (3) The burnt land by the byres (site of quadrat 2) was tested in 3 places in September 1955, and figures were obtained in the range 5·5 to 6·5. A figure within this same range (pH 6) was obtained from the ash of the much more recent fire west of the main Lighthouse Tower (quadrat 5). (4) The most basic readings obtained were from the cinder path leading to the Observatory where *Barbula recurvirostra* grew, crannies just near-by where *Barbula convoluta* was taken and just outside the back door of the Observatory—

now the site of a small colony of *Marchantia polymorpha*. In all these instances the pH was 8. There is no doubt that the bulk of the ledge habitats on the island—where most of the bryophytes occur—have a substratum which is mildly acid. Extremely acid habitats are lacking. One would have expected a history of decreasing pH on the site of the big 1949 turf fire by the byres, and it is a little odd that in 1955, at the outset of this experiment, the figures obtained were the same as, or very close to, the figure for the recent fire by the Tower. By 1955 *Funaria* was already "on the way out" at the byres site, and only scattered old plants could be seen; nor was it noted in subsequent seasons. One must suppose that in the seasons immediately following the 1949 fire the pH was considerably higher.

The six special areas considered in the account that follows, each with its permanent quadrat, were: 1. A grassy ledge site, Colm's Hole. 2. Site of 1949 deep turf fire, by the byres. 3. Bank of seasonally dried-out pool, South Plateau. 4. Ledge with fescue and *Armeria* and moss colonists, by the loch (north-facing aspect). 5. Site of the recent (1955) fire, west of main Lighthouse Tower. 6 Rock outcrop immediately west of Beacon. This was added in April 1958 and no account is given of the outcrop as a whole on which the quadrat rests.

DESCRIPTION OF THE AREAS AND RESULTS OF CHART STUDIES.

(1) *Colm's Hole.*

The hummocky, grass slope, as one descends into Colm's Hole, is mainly dominated by *Holcus*. There is some *Festuca* in the turf and here and there a detectable patch of *Agrostis tenuis*. But the overwhelming majority of flowering heads are those of *Holcus lanatus* and it is this grass which forms most of the hummocks, perhaps 5 to every one of fescue. The sward on this North-facing slope was green compared with most of the island in the 1959 summer of drought. Despite pressure of grazing by sheep* and by an increasing number of rabbits, the grass was still thick and tussocky, with turf height of 6-9 (-12) inches, excluding inflorescences. *Armeria* plays a part, particularly around outcrops, where nesting gulls have often worn it and the associated fescue brown, and, together with excavating rabbits, have created patches of bare earth locally. As regards grazing,

*There are now (1959) 100 head of sheep on the island.

one gets the impression that there is some selection, fescue being more severely grazed than *Holcus*.

The south-facing northern half and the north-facing southern half of the amphitheatre are to a great extent a study in contrast. The former is often denuded, has much *Armeria* and almost no declivities available for bryophytes. The latter—north-facing and always sheltered by the steep fall of the slope from direct insolation—provides at the base of each major bluff an ideal recess for bryophyte colonisation. The mosses and liverworts which occur there grow on bare, dark, peaty soil; apart from the advantages of aspect and slope steepness, they enjoy protection from over-hanging tussocks of grass. Often the grass has to be parted to see them in their deep recesses, and it is especially notable that in September 1959, even after months of almost unprecedented drought, the hollows where they grew were still plentifully moist. Two of the more exacting (and elsewhere on the island unknown) species, *Hookeria lucens* and *Anthoceros husnoti,* were flourishing in September 1959 better than I have seen them on any previous occasion. So also were *Fissidens bryoides, Calypogeia fissa* and other species, some like *Eurhynchium praelongum* and *Mnium hornum* being important colonists here whilst also occurring very widely elsewhere on the island. *Hookeria* occurs in a few recesses only, namely those rather high up the north-facing slope. *Anthoceros* is found in several, a little lower down, within a few yards of the permanent 20 cm. quadrat. This quadrat was set up to study the changes undergone by the bryophyte element in the practically "closed community" of the turf itself and as such is dealt with separately. Some of the species concerned are entirely different from those found in the declivities, although others, such as *Eurhynchium praelongum, Lophocolea cuspidata* and *Mnium hornum,* are found in both sites.

A further, and rather different "outburst" of bryophytes may be seen at the base of the rocky bluffs which rise from the foot of Colm's Hole, in the centre and southward from it. The principal notable species here are *Isothecium myosuroides* var. *brachythecioides, Bryum alpinum* and, rather locally, *Frullania germana. Frullania tamarisci* and *Bryum capillare* also occur. The impression gained after the summer drought of 1959 was that both *Bryum alpinum* and *Frullania germana* were "holding out".

Although their characteristic habitat of rock faces dripping with water in a normal season had been locally much desiccated. *Isothecium* still abounded, especially on the ledges where turf cover and rock outcrop met. In places there were signs that it was being smothered by rank grass. These lowest ledge sites, also north or north-east facing, bear a fair quantity of the widespread mosses *Eurhynchium praelongum* and *Mnium hornum*; and on the rock face, cushions of *Grimmia maritima.*

Certain bryophytes, for example *Mnium punctatum* and *Riccardia sinuata,* noted on a previous occasion in very small amounts, were not seen again in 1959.

All in all, this little amphitheatre, about 90 ft. deep, and little more than 50 yards wide, is the richest area bryologically on the island. The really productive area does not amount to more than some 400 sq. yds. of steeply sloping, irregularly broken ground. Viewed from above, Colm's Hole gives no hint of this wealth and in a casual inspection from the path passing along the top of it literally no moss can be seen.

The Colm's Hole Quadrat.

The general picture is one of increasing domination by the grass *Holcus lanatus,* associated all the while with some fescue. In the process a lichen (*Peltigera* sp.) and the flowering plants *Senecio jacobaea* and *Sagina procumbens* have disappeared from the square. One gets the impression that at the outset the square was caught at a phase in re-colonisation, having at some earlier stage been partly or wholly bare of turf—hence the greater diversity of species of higher plants at the opening stage of the experiment. Over the 4 years it has built up to a position of almost complete dominance of *Holcus lanatus,* but *Rumex acetosa* is still retained in the turf and no doubt in season *Ranunculus ficaria* is conspicuous.

Events regarding the bryophytes have been interesting. At the 1955 stage, with the ledge imperfectly grass-covered, *Hypnum cupressiforme* and *Rhytidiadelphus squarrosus* were both conspicuous and fairly abundant. They alone were recorded both then and in May 1956. By April 1958 these 2 bryophytes had become much scarcer and traces of *Lophocolea cuspidata* and of *Eurhynchium praelongum* were noted in one corner. By September 1959 it would seem as a result of the bunching up of the big

Holcus plants, which then created sheltered pockets or hollows of nearly bare or bare soil under them, the 2 latter species had increased markedly. The *Rhytidiadelphus* and the *Hypnum* have not been eliminated but survive in the form of small and slender shoots. One or two shoots of *Mnium hornum* were recorded in 1956 but do not appear to have persisted.

(2) *Site 50 yards east of byres: burnt turf regeneration cycle.*

This is an area of about 35 yards by 25 yards, of irregular shape, containing numerous fairly flat outcrops of basaltic rock and with the soil in the main shallow. In September 1959 it stood out from the surrounding terrain by reason of the immature character of the turf which not only still carried much bare or nearly bare ground but was also marked by the prevailing whitish-brown of the *Holcus* tufts, in contrast with the green of the adjacent sward. It is true that in the dry summer of 1959 the grass almost everywhere appeared much browner than usual, but the comparatively young *Holcus* of this patch of ground, doubtless because relatively shallow-rooted, had suffered particularly severely. Often the tufts appeared completely dead and brown, but dissection usually revealed living shoots within.

The position in 1959, after 10 years of the process of recolonisation, was that one had a mosaic made up in the main of *Holcus lanatus* (as isolated or confluent tufts), *Sedum anglicum* and *Ceratodon purpureus*. *Holcus* was very much in the ascendancy, *Sedum* was being widely superseded (it was noted as an early colonist†) and *Ceratodon* was chiefly conspicuous around the rock outcrops where the soil covering was very thin. One can foresee the re-establishment of continuous *Holcus* sward at a not very distant date but it is of some interest that even 10 years after the fire this situation had by no means been achieved. It should be stressed that this was no ordinary superficial "bonfire", but rather one that smouldered for weeks at a time, burning deep into the turf and changing those surface layers of soil which are here very rich in organic content to a fine, friable brick-red powder. The story of its total recovery might thus be expected to be a long one.

†See entry in Observatory note-book, 22nd September 1950, when Prof. M. F. M. Meiklejohn remarked that it was not only the first plant to re-colonise the burnt area but also that it did so rapidly.

Observations made intermittently over the 10 years give some idea of the succession of events and those made more continuously on the marked quadrat over the past 4 years amplify this. The essentially open nature of the community has throughout tended to make for a varied flora and even at its September 1959 stage the regenerating vegetation was marked by a fair assortment of species. The following were noted as occurring:

Flowering plants:

HOLCUS LANATUS
SEDUM ANGLICUM
ARMERIA MARITIMA
PLANTAGO CORONOPUS
FESTUCA OVINA
AIRA PRAECOX
SAGINA PROCUMBENS
*RUMEX ACETOSA
*SENECIO JACOBAEA
*CERASTIUM VULGATUM

Cryptogams:

CERATODON PURPUREUS
CLADONIA RANGIFORMIS
CLADONIA FIMBRIATA f. CONISTA
CLADONIA SUBCERVICORNIS
PELTIGERA SPURIA

My impression was that there had been little change since a year and a half before, but that *Sedum anglicum* and the lichens had tended to decrease, whereas *Holcus* had spread greatly. Some *Ceratodon* had fruited in Spring 1959 and the status of this species remained high.

The Byres Quadrat.

This has been a story of a rapid increase in the number of species represented. In September 1955 the square was jointly dominated by *Ceratodon purpureus* and *Sedum anglicum*; there were several plants of *Sagina procumbens,* but that was all (Fig. 1a).

By summer 1956, *Sedum anglicum* had increased at the expense of *Ceratodon,* several discrete "islands" of it becoming confluent. *Aira praecox* had invaded in 3 places, *Sagina procumbens* seedlings abounded (in addition to the mature plants) and there was one seedling of *Plantago coronopus.* By spring 1957 a single seedling of *Senecio jacobaea* had invaded but the other components remained much the same, with *Sedum anglicum* still very prominent. The plant of *Plantago coronopus* had established itself.

*Only casuals in the community in September 1959.

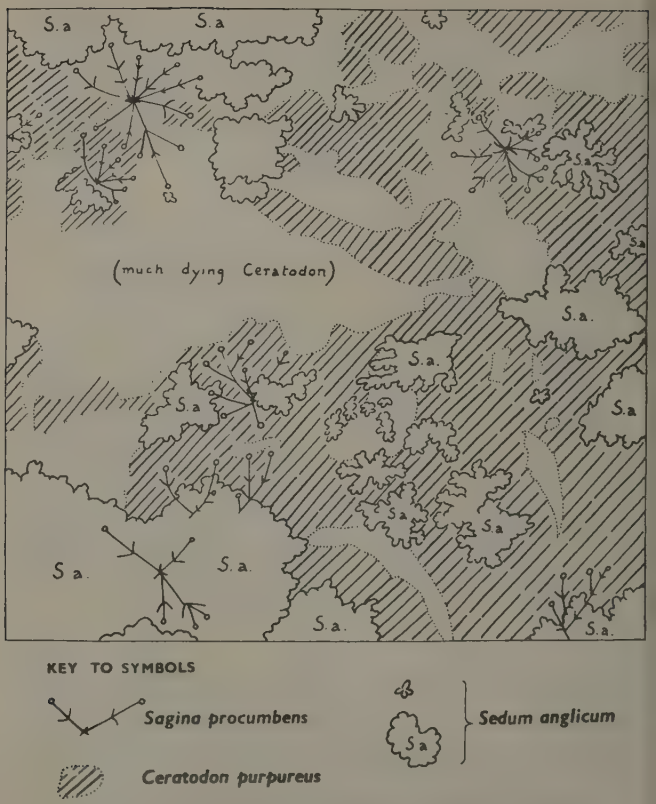

FIG. 1a.—Byres burnt area quadrat. September 1955.

April 1958 saw a sharp change, with the advent of at least 3 species of lichen and invasion by *Holcus* at 5 points. *Sagina procumbens* had increased greatly, the area covered by *Ceratodon* had contracted somewhat and *Sedum anglicum*, although still plentiful, appeared less healthy under the stress of competition with other plants. The record of September 1959 was chiefly remarkable for the overwhelming increase in cover by *Holcus*, mostly at the expense of *Sedum anglicum*. *Sagina procumbens* and the lichens were still important, 4 young plants of *Plantago*

FIG. 1b.—Byres burnt area quadrat. September 1959.

coronopus replaced the one original invader and one plant of *Festuca* had arrived (Fig. 1b). It is plain that the future will lie in fairly speedy advance (probably in fact reversion) to *Holcus* sward, but it is impossible to say just how long this will take.

Where soil is very thin around outcropping slabs of rock, *Ceratodon, Sedum anglicum* and perhaps the lichens are likely to persist indefinitely. *Sagina procumbens, Aira praecox* and *Plantago coronopus* seem to have been essentially plants of the seral stages and are unlikely to survive long in the face of the advancing *Holcus*.

(3) *South Plateau: Dried out pool.*

The one with the marked square is the largest and most westerly of 3 such pools (others, not dissimilar, occur on the North Plateau). It is about 20 yds. long by 10 yds. wide. It represents a level depression, surrounded by ground which varies from 6″ to 3′ higher than itself. The 6″ embankment occurs at the west end and doubtless provides an outlet for water when the water table is high and the pool exceptionally full. From this point the ground falls away to the west cliff but no obvious channel has been formed. Ordinarily the water table fluctuates between far below and some 4″ above the soil surface. After drying out the soil surface tends to crack, and in September 1959, following the drought, it had broken up extensively into lumps and crumbs varying in size between a pea and a walnut. This gave it a friable and almost tilled appearance and where this had occurred most markedly colonisation by plants was down to a minimum—widely scattered rosettes of various species. This condition could have been induced perhaps by animal disturbance of the brittle crust which would arise after initial cracking. Among the chief colonists of the soil surface were:

Atriplex spp.	Festuca spp.
Poa spp.—probably mainly P. annua	Holcus lanatus
Sagina procumbens	Juncus bufonius
	Callitriche stagnalis

When visited in 1959 only the north-facing soil bank, over-arched by grassy turf, was moist and sheltered enough for bryophyte colonisation. This, too, has usually been so in the past so far as I am aware, although it is not true of the North Plateau pools. The latter tend more readily to acquire an over-all bryophyte cover and even in 1959 showed extensive colonisation by *Drepanocladus fluitans* and others.

The South Plateau Pool Quadrat

Since about half or slightly more than half the quadrat is covered by water each winter (as the water table in the shallow pool rises) this lower half and the more or less permanently exposed upper half are best considered separately. Each presents a picture of bryophyte succession operating cyclically, but the two are different, chiefly in the rate of the cycle.

Taking the lower part of the quadrat (that liable to submergence) first, one finds a certain lack of continuity between the charts of September 1955 and May 1956, but this lack of continuity is less than would have been expected had the bryophyte cover been completely obliterated by winter flooding. Thus, most of the shoots of *Lophozia, Lophocolea* and *Eurhynchium praelongum* were in much the same position in the square in May as they had occupied the previous September. Yet there is little sign of growth in the intervening 8 months. One must conclude that in respect of these three species flooding acted as a check but did not prevent recovery. The same is true of *Mnium hornum,* but in this case scattered new young shoots had appeared by May 1956. Young acrocarpous mosses, chiefly *Pohlia delicatula,* had not quite recovered by the following May the area held by them in September 1955. A plant of *Sagina procumbens* had been replaced by a group of its own seedlings, and two little plants of *Juncus bufonius* had been killed by submersion and left no visible successors.

It may be mentioned that in addition to winter flooding the depredations of Kittiwakes in search of mud for their nests may be a potent factor in keeping down recolonisation in this lower half of the quadrat. When Dr. Eggeling kindly studied the area on 29th May 1957 he formed the impression that gulls had been an important influence. The whole of the lower half of the quadrat consisted of bare mud, even at that advanced date in spring (and in contrast with 1956), and the beak marks of Kittiwakes were clearly visible. In April 1958 water covered all this lower half and only mud could be seen beneath it. It is thus not surprising that when the square was mapped in September 1959 the precise pattern formed by the various plants upon it bore no close or obvious relation to anything that had gone before. They presented some 5 months of growth and although the distribution of young *Mnium hornum* and *Lophozia ventricosa* shoots

bore some resemblance to what had gone before one cannot be certain that after submersion and "mud-scouring" by Kittiwakes any tiny fragments did in fact remain from which they could grow. It is possible that this did happen but it is also possible that the 1959 bryophyte cover represented a wholly new colonisation. Suffice it to say that a remarkably similar *general* picture was achieved to that of 4 years earlier.

Of the flowering plants, too, the same could be said. Straggling *Sagina* and small rosettes of *Juncus bufonius* were there as before, but in new positions. A plant of *Holcus* replaced an earlier plant of *Agrostis stolonifera,* however, and *Sedum anglicum* was a new colonist.

The upper half, or at any rate the upper third of this square is unlikely to have been seriously flooded, but it of course is not immune to the depredations of Kittiwakes, and since the angle of slope approaches 70° towards the top of the quadrat the soil is likely to be unstable. No flowering plants have entered this upper, steeper half of the square. Colonists in the form of *Lophozia ventricosa, Lophocolea* sp. and *Mnium hornum,* together with small acrocarpous mosses, that had been present in September 1955 were identified again and had made some growth in a number of cases by May 1956. One could have expected more growth and it is entirely possible that much of the upper half of the quadrat was also flooded for a time in mid-winter. Many colonies of young "acrocarps" towards the upper limit of the quadrat appeared in May 1956 to be over-run by an unidentified powdery white lichen.

Because of the Kittiwakes and perhaps also because of periodic flooding only the extreme uppermost strip of the quadrat (overhung somewhat) can present any real continuity, and even that is apparently a short term cycle only. For April 1958 revealed a continuous carpet of *Lophozia ventricosa,* with a few plants of *Dicranella heteromalla* here, and out-lying *Lophozia* spreading downwards; a complete change from May 1956 and one which suggested almost total baring of the ground and subsequent recolonisation. By September 1959 much of the *Lophozia* was old, going brown and tending to break up; farther down it was still young and green and appeared to have advanced little on its position of April 1958. Meanwhile, a carpet of new colonists had appeared on the bared soil, various acrocarps, chiefly *Pohlia*

delicatula and in places a species of *Cephaloziella*. *Mnium hornum* appeared to be coming in as successor to *Lophozia* along the top margin of the square. *Pseudephemerum nitidum* fruited amid the Pohlia carpet, as it had in September 1955, on ground adjoining the square.

Summarising, one can detect on this upper, steeper slope, a bryophyte succession which can at any point be checked or reversed by flooding, by soil erosion or by bird depredation. Many species can be primary colonists but ultimate dominance seems most readily to be achieved by *Lophozia ventricosa*. Two seasons of continuous growth are, however, sufficient for this to become "top-heavy" and unstable, when it will tend to break away, giving bare patches on which the cycle may then begin once again. *Mnium hornum* may encroach at such times, but there is no sign of effective invasion by flowering plants.

(4) *Area at Base of North-facing Slope, by the Loch.*

The plot is at the sloping base of a 1-3 ft. terrace, the angle of slope being about 20°, or slightly less. The terrace itself is at the foot of a steeper fescue slope (angle of slope 30-35°) which also carries some *Agrostis* in the turf. Here *Armeria* "hassocks" of some antiquity are prominent and they would appear largely responsible for the terracing effect in the main slope itself. These are green-topped but have up to 1 ft. to 1 ft. 3 in. of brown decaying base. The whole area under study is one of active recolonisation. There are many sq. ft. of unstable, bare, peaty soil to the east of the plot—on which bare soil *Atriplex* sp., *Glaux maritima* and *Sagina maritima* are temporary invaders. This soil is also colonised by *Bryum intermedium* and *Pottia heimii*. In September 1959 one saw several young *Armeria* cushions 1-5 in. across, but some of these must have been 5-10 years old at least, to judge from the slow rate of change of the one in the plot itself. The position in 1959 was that **Festuca rubra* was colonising rapidly, at least in places, including the plot itself. It seems that *Ligusticum* is then able to come into the fescue secondarily. There was one minute seedling in the plot.

It is possible to suppose that, if the line of *Armeria* cushions continues to build up, a new terrace could be formed in, say, 25

*According to Dr. W. J. Eggeling (1956) *Festuca rubra* (incl. var. *barbata*) is the dominant grass on the island.

or 50 years. On loose stones in the terrace embankment were *Xanthoria parietina* and *Ramalina scopulorum*. *Armeria* can colonise either direct on the soil or by way of a pre-existing moss carpet.

Comparable events seem to have occurred on the south-facing slope with the important exception that it is too dry and exposed for the extensive moss carpet to form and presumably for the same reason it bears no *Ligusticum* whatsoever. One concludes that in the march of colonisation, terrace formation, erosion and recolonisation (by the leading plants *Festuca* and *Armeria*) the moss carpet is purely incidental. The whole area is highly susceptible to salt spray on a west wind.

The Loch-side Quadrat.

At the outset in September 1955, some 70% of the area was covered by a growth of acrocarpous moss in the form of a "short turf" (mainly *Bryum intermedium* and some *Pottia heimii*), and in this turf some 30 plants of *Sagina maritima* (small but flowering) could be seen (Fig. 2a). There were 4 young plants of *Festuca rubra*. One plant of *Armeria* appeared in the bottom right-hand corner and three young rosettes were noted elsewhere. About 20% of the area was bare soil. May 1956 revealed little change, except that the young *Armeria* was being smothered by coalescing *Festuca*, all the *Sagina maritima* plants had gone, giving place to a great number (100+) of seedlings of that species, and some of these together with the extending moss "turf" had covered all but a very little of the bare soil.

Mr. I. H. B. Munro and Dr. W. J. Eggeling kindly reported the position in May 1957. This represented an advance of *Festuca*, with coalescence of tufts and little notable change in moss turf or in the original corner plant of *Armeria*. A few *Sagina maritima* seedlings were dotted about. Mr. Munro noted some disturbed soil which he attributed to the depredations of Kittiwakes in search of nesting material. By April 1958 more *Festuca* plants had sprung up apparently from seed and the rather sickly-looking moss turf had contracted a little in extent and had been invaded locally by a dark brown lichen (*Leptogium sinuatum* var. *scotinum*). *Sagina maritima* seedlings were again numerous and the one *Armeria* plant showed no appreciable change. In September 1959, after the passage of a further two growing seasons, *Festuca rubra* was covering some 70% of the quadrat, largely as a

continuous sward; there were no *Sagina* plants visible and the moss carpet, although surviving, had contracted further. The *Armeria* plant had altered little throughout the experiment. One seedling of *Ligusticum scoticum* had established itself in the *Festuca* sward (Fig. 2b). Thus, summarising for this quadrat, one had seen in the course of 4 years the main events of a succession, as follows:

(Preceding phase of bared ground assumed.)

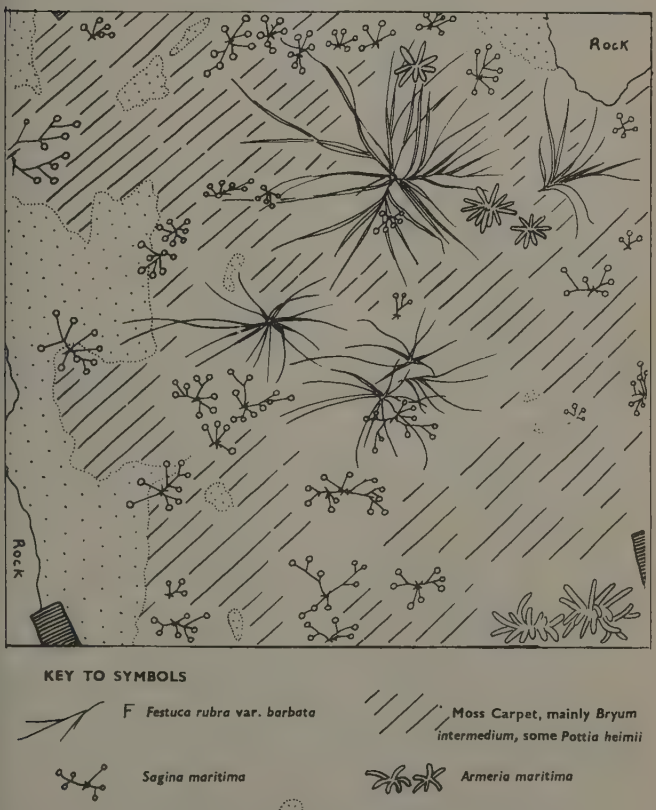

Fig. 2a.—Loch-side quadrat. September 1955.

Fig. 2b.—Loch-side quadrat. September 1959.

*Bryum intermedium** and *Pottia heimii* as moss colonists, together with *Sagina maritima* and *Festuca rubra* as flowering plant colonists → Increasing dominance of *Festuca* and gradual elimination of *Sagina*, together with some contraction and loss of

*It is possible that *Bryum* succeeds *Pottia* but I have not enough evidence to be sure of this. The dense moss turf of 1959 was almost wholly *Bryum*.

vitality in the moss carpet which was locally invaded by lichen → Still further advance of *Festuca* and contraction in amount of moss cover, with advent of *Ligusticum* seedling.

It is hard to see that the moss turf here has done anything to prepare the way for the flowering plant succession. It and the *Festuca* were together present at what must have been an early stage in events (the start of observations) and the fescue spread as a result of its own growth and seedling production. The moss seems to be purely incidental, although its presence may have assisted in the establishment of *Festuca* seedlings. At any time the moss carpet can revert to bare ground under the impact of Kittiwake attack or other erosive influences. Once the *Festuca* sward is established this reversion to bare ground is less easily brought about.

5) *The burnt area at a point 100 yds. west of Lighthouse Tower.*

This is on thin soil and appears to have been quite a superficial burn which took place in summer 1955. The area was blackened at the start of the experiment in September 1955. It is surrounded by *Festuca-Holcus* turf, whilst 5 yards to the north-west of it lies a long bed of nettles and thistles in a narrow hollow or gully. Through much of the area, which is but a few square yards in extent, rock outcrops as flat slabs, and it is possible that more of this has been exposed since the fire by soil erosion.

In September 1959 the burnt area had partly recolonised to form continuous *Holcus* sward—e.g. in the marked square itself. Elsewhere, on the very thin soil, *Ceratodon* was very prominent and scattered *Sedum anglicum* occurred freely. There was still some bare reddish black burnt soil which had a strong tendency to break away and be scattered in little chips or flakings, often with its thin and insecure cover of *Ceratodon*.

There had obviously been some *Aira praecox* in Spring, but I cannot say for certain that any other species than these few occurred as a fire regeneration colonist here. A few plants of *Armeria* to the east end of the patch looked old enough to have survived the fire and were unlikely to have reached the size of mounds 4 in. to 5 in. across in 4 years.

The quadrat by the Tower.

This quadrat, on burnt ground, was bare in September 1955 and bare, save for a small trace of alga, in May 1956. Thereafter

re-colonisation was speedy and presented a rapidly changin picture.

Dr. W. J. Eggeling kindly mapped the quadrat for me i May 1957 and at that time the following invading species ha arrived: *Aira praecox, Sedum anglicum, Holcus lanatu Chamaenerion angustifolium* (1 seedling), some moss—from sub sequent observations I deduce that this was mainly *Ceratodo purpureus.* Dr. Eggeling estimated that the total cover was abou 90% of the quadrat, Angiosperms accounting for approximatel 70% and bryophytes 20%. By far the most abundant colonist a this stage was *Aira praecox* and although there was a massiv plant of *Holcus lanatus* near at hand that species had only jus begun to invade the quadrat itself. *Sedum anglicum* had arrive in a number of places and one may allude to this as the *Sedum Aira-Ceratodon* stage in the burn regeneration cycle.

By April 1958 *Aira* tufts had become more numerous and con fluent in several places, and this species still covered slightl more of the quadrat than any other single species. It had i fact apparently gained ground on the preceding year throug what seemed to be seedling progeny of 1957 "mother plants" *Sedum* and *Ceratodon* were still important in the vegetation an their status appeared to have altered little. The one big chang was the advance of *Holcus* which had extended in some places a the expense of *Sedum* and was by this time second only to *Ai* in abundance in the quadrat as a whole. *Ceratodon* plants fo the most part looked brown and rather unhealthy, so that it wa plain that they were ageing gametophytes of the previous season The *Chamaenerion* seedling had not survived, but a newcomer t the square was *Rumex acetosa*—in one place only. This ma perhaps be called the *Aira-Holcus,* or the *Aira-Sedum-Ceratodon Holcus* phase in the recolonisation.

When two more growing seasons had passed and the area wa revisited in September 1959, the entire quadrat was a continuou *Holcus lanatus* sward. Nearby, outside the quadrat, traces of th former pattern survived, but it was plain that a third and fin phase of complete domination by *Holcus* was in sight.

It is significant that this, which must have been a small-sca fire on thin soil, should have passed through its cycle of regener tion so swiftly, and in this it contrasts with the deep, long smouldering turf fire of 1949 which formed the site of the byr

quadrat; for there regeneration has been very gradual and the cycle—though moving towards a *Holcus* sward—remained after 10 years a long way from completion.

(6) *The rock quadrat, west of the Beacon.*

This quadrat was set up and first mapped only in April 1958, so that it is too early to draw much by way of conclusions from it. It was set up in an attempt to provide an answer to a number of questions which posed themselves. About 70% of the area was rock outcrop and one question was whether over a period of years surrounding soil and turf would gradually encroach on this rock or whether the forces of accretion and erosion would remain more or less evenly matched for a long period of time. Then again, the area was selected with some care to include several cushions of the uncommon moss, *Grimmia stirtoni,* and one wished to know whether these neat, rounded cushions remained relatively static for considerable periods, exhibiting a very slow rate of growth, or were subject to quite rapid change. Thirdly, the rock outcrop was the habitat of several species of encrusting lichens and it would be of interest to know something of their rate of growth; it was thought that accurate chart quadrats could furnish such information.

To give a brief interim report on this quadrat, one can state at once that 18 months is too short a time to see, or expect to see, any appreciable change in the proportion of the area covered by the rock outcrop; one can go on to report a quite remarkable extent of change in the colonies of *Grimmia stirtoni,* even in that short time, but with the estimate of cover by different lichens one runs into certain difficulties. These last two points, change in the *Grimmia* colonies and the assessment of the lichens, call for rather fuller explanation.

Four colonies of *Grimmia,* each about 1 cm. in diameter, had been largely lost, only 2 small fragments remaining. Two further colonies, slightly larger than the above, were represented 17 months later by small intermittent tufts only; and in a different part of the quadrat 4 new small colonies had established themselves, each about 5 mm. in diameter. The bare, reddish brown rock surfaces from which the *Grimmia* cushions had come away were very obvious. It appears that when a cushion attains a certain size it is unable to withstand the dislodging influence of

heavy rain wash. It would also seem that this maximal size is quite swiftly achieved. Further, the same influence which can dislodge a tuft can establish new fragments of gametophyte elsewhere—hence the new colonies. For there are no capsules.

With regard to encrusting lichens it is impossible to say much beyond the fact that the general pattern of different species on the rock had altered little in 17 months. One is hampered, however, by imperfect knowledge of the different forms that may be assumed on occasion by the same species, and hence by the impossibility of discriminating accurately at times between the various immature lichen states that may be present. The more clearly defined colonies at all events had altered little in position or extent.

On the peaty soil that flanked the outcrop there was some evidence from the charts that *Holcus lanatus, Festuca rubra* and *Polytrichum piliferum* had all increased cover, whereas *Sedum anglicum* and probably also *Aira praecox* had decreased. This would be a trend in the same direction as that followed by the burn regeneration cycle on the fired quadrats, but owing to the unstable character of the thin soil (on the rather steep slope) abutting on the outcrop one would suspect that anything approaching continuous *Holcus* sward might never be achieved. Only a longer period of time can reveal the trend more clearly.

SUMMARY OF MORE IMPORTANT CONCLUSIONS, WITH SPECIAL REFERENCE TO THE BRYOPHYTE ELEMENT.

(1) With increasing density of the sward at Colm's Hole the bryophyte flora has changed. *Rhytidiadelphus squarrosus* and *Hypnum cupressiforme* in the turf have tended to give place to shade-tolerant *Eurynchium praelongum* and *Lophocolea* which survive beneath, and in the shelter of, big, tussocky plants of *Holcus lanatus*. *Peltigera* has been eliminated in this process.

(2) Change has been slow on the fired site by the byres. Certain lichens (*Cladonia fimbriata* f. *conista, C. rangiformis, C. subcervicornis, Peltigera spuria*) entered the community at a relatively late stage. The *Funaria* stage was over when the experiment began and there has been a long-term advance through a *Sedum-Aira-Ceratodon* phase towards a *Holcus* sward. *Ceratodon purpureus* has been long persistent as a principal component in the essentially open community. So, too, has *Sagina procumbens*.

(3) Bryophyte development on the soil bank of the dried-out pool on the South Plateau is shown to be cyclical, the rate of the cycle depending on the extent of winter flooding and periodic bird depredation. *Lophozia ventricosa* can reach senescence in about 2 seasons if subject to no interruptions in its cycle of development. It appears that in the flood zone only species able to pass through their life cycle rapidly can achieve fruiting (e.g. *Pseudephemerum nitidum*) in the short time at their disposal.

(4) It seems likely that the moss carpet is purely incidental in the advance to *Festuca rubra* sward on the loch-side quadrat. It is shown that the "short turf" of *Bryum intermedium* (with a little admixture of *Pottia heimii*) can survive little altered for 4 years at least; but it shows signs of gradual senescence and decreasing growth rate. *Sagina maritima* has been eliminated in the process.

(5) The site of the superficial fire west of the lighthouse tower has passed through a rapid cycle of regeneration. In 4 years it has changed from bare ground, through a *Sedum-Aira-Ceratodon* phase, to a phase dominated by *Holcus*. This contrasts with site 2, where the fire was of much deeper penetration.

(6) Even in the period of 17 months the distribution and relative size of colonies of *Grimmia stirtoni* on the rock outcrop quadrat have changed remarkably. The limits of various encrusting lichens were, as anticipated, little altered in this time. It is too early to draw much by way of conclusions from this sixth quadrat.

GENERAL CONCLUSION.

This study has allowed the comparative precision of the chart quadrat method to bear on the problem of the rate and character of change in some selected bryophyte communities. It is perhaps little more than a beginning, for even as regards these sites 4 years is not a long time, and the chosen examples are few. However, it has illumined processes that might otherwise have passed unnoticed; and this is especially true where the passage of years brings one back to something looking very like the condition at one's starting point. In the last analysis much vegetational change is like this and many plant successions are long term or short term cycles of events. On the Isle of May, which by reason of its extreme exposure to sea winds and its

prevailingly thin soil covering is tree-less, the story of succession is little more than the sequence of events from bare ground to turf cover. Erosive forces begin to operate, fire, bird depredation, excessive grazing pressure and others, and bare ground is found again. This paper has attempted to trace the rôle of bryophytes in some of these events and in doing so has demonstrated the underlying tendency of vegetation to restore the *status quo*. It is often indeed true to say, "plus ce change, plus c'est là même chose".

ACKNOWLEDGMENTS.

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Montane Plants in Ross-shire and Sutherland.

By Derek A. Ratcliffe
(The Nature Conservancy, Edinburgh).

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The most celebrated places for montane plants on the mainland of Northern Scotland are the limestone exposures at Kishorn, Knockan, Inchnadamph and Durness, and the blown shell-sand area at Bettyhill. These all lie at low levels and the richness of their flora contrasts with the poverty of a great deal of the high ground. For a long time, Ben Hope was the only one of the higher hills known to have a flora of comparable quality, and though the mountains of the region had yielded many interesting species, these had seldom been found together in any number.

More recent exploration of little-worked country in Ross-shire and Sutherland has shown that at least three hills vie with or even surpass Ben Hope as stations for montane plants, and that several of the rarer species extend much farther north in the Highlands than had seemed likely hitherto. Many of the discoveries have been recorded in the literature, perhaps the most notable being those made by Messrs. E. C. Wallace and R. MacKechnie (1954) on the Beinn Dearg range above Loch Broom. This account does not attempt to review all the advances in knowledge of montane plant distribution within the region, but to place on record more recent finds made by the writer and to indicate the localities where further search may be profitable. Since this will deal mainly with rare and local species it is felt that some mention should first be made of the more widespread element of the montane flora to be found on many of the hills which will be mentioned.

Because of the predominance of non-calcareous, acidic rocks, calcifuge and indifferent species tend to be the most widespread and abundant members of the montane flora throughout the Northern Highlands. Owing to varying habitat preferences with regard to soil moisture, snow-cover or exposure, altitude, and freedom from competition, these plants may occur in very different communities and some are always more abundant than others. A number are, however, present in all the main massifs and so form the usual basis of the montane flora. The widespread calcifuges are *Arctous alpina, Carex pauciflora, Chamaeperi-*

clymenum succicum, Gnaphalium supinum, Juniperus communis ssp. *nana, Loiseleuria procumbens* and *Rubus chamaemorus. Arctous* is one of the most notable plants of the Northern Highlands, for it is abundant on exposed spurs and in blanket-bogs on many hills, in contrast to its scarcity or absence to the south of the Great Glen. A few other species of this group are local in their abundance. *Betula nana* occurs mainly on the eastern side of the main watershed of the Northern Highlands, though the blanket-bogs which form its habitat are extensive in the far west. *Lycopodium annotinum* is found mainly in the Ross-shire hills, both eastern and western, and becomes scarce in Sutherland.

The widespread indifferent species are *Alchemilla alpina, Arctostaphylos uva-ursi, Carex bigelowii, Empetrum hermaphroditum, Epilobium anagallidifolium, Juncus trifidus, Luzula spicata, Salix herbacea, Saxifraga stellaris* and *Vaccinum uliginosum.* These grow on most calcareous cliffs as well as in various types of montane heath on the high slopes and summits. On most high tops in the western half of the region, above 2,500 ft. or even less, *Silene acaulis, Cherleria sedoides* and *Armeria maritima* occur in profusion in *Rhacomitrium* heath, here behaving with complete indifference to the lime content of the soil, for the parent material is often quartzite or Torridon sandstone. This is the community described by Blake (1957) for Foinaven in Sutherland. All three of these cushion herbs occur plentifully on most of the more elevated calcareous cliffs in the Northern Highlands.

Cryptogramma crispa and *Athyrium alpestre,* which are here regarded as indifferent species, are widespread but decidedly local and occur most usually in characteristic late snow-bed communities in rocky corries of the highest hills. These ferns appear to need protection from winter frosts in the colder districts of the Highlands (McVean and Ratcliffe, in preparation) but in the most oceanic areas, such as Applecross, the Parsley Fern occurs more widely on the hills. *Athyrium alpestre* is always restricted to higher levels, but probably its finest Scottish station is on Beinn Bhan in Applecross, where it dominates huge ungrazed ledges on a terraced corrie escarpment.

Cardaminopsis petraea and *Cerastium arcticum* are abundant on some hills, on both basic and acidic rocks, but have a very irregular distribution and are best represented in West Ross.

The distinctive hawkweed *Hieracium holosericeum* grows rather sparingly on many of the higher hills, on dry rocks and in montane prostrate *Calluna* heaths. *Sibbaldia procumbens* does not grow on the very poorest substrata, and though it occurs over a wide range of soil base-status it is, like *Alchemilla alpina,* most abundant on calcareous mountains. This species favours ground where snow lies late, and so is rare in Sutherland, where few hills carry long-lasting snow beds.

Wherever calcareous rocks outcrop, especially at elevations above 1,000 ft., there is a marked increase in the number of montane plants. Some of these calcicoles are common to all or most extensive exposures of suitable rock at higher levels, and with the ascending lowland and indifferent species they form the heterogeneous complex of cliff vegetation ranging from tall herb communities of broad, stable ledges to the chomophytic types belonging to unstable rock-face habitats. Some are equally at home in calcareous springs, flushes and mires, either adjoining or away from the cliffs, and a few of the rarities are confined to such habitats. The widespread species, present, though in varying abundance, on nearly all the calcareous cliffs which will be mentioned, include *Asplenium viride, Cochlearia alpina, Epilobium alsinifolium, Galium boreale, Juncus triglumis, Oxyria digyna, Polygonum viviparum, Polystichum lonchitis, Rubus saxatilis, Saussurea alpina, Saxifraga aizoides, S. hypnoides, S. oppositifolia, Sedum rosea* and *Thalictrum alpinum.*

Further increases in richness of the montane flora consist mainly of additions to the calcicolous element. Only a few other calcifuge or indifferent species can be added from the whole region to the list already given, and rarely do more than one or two of these appear on the same hill. On the whole, the rarer species tend to favour high altitudes, though there are exceptions, such as *Ajuga pyramidalis* and *Oxytropis halleri.* Floristic richness thus comes to be associated with the extensive occurrence of calcareous rocks at high elevations, a very local condition in the Northern Highlands.

Perhaps the most notable locality in the region is the range of Seana Bhraigh (3,040 ft.) lying several miles to the north of Beinn Dearg and forming part of the main watershed. The most productive parts of this tract are the cliffs at the head of Glen Douchary, which drains west to Ullapool and so lies in West

Ross, and the north-facing corries, Loch Luchd Coire, Coire Mor and Glasha Burn, all situated within the catchment of the Oykell, in East Ross. The whole massif is composed of Moine rocks varying from the usually acidic granulite to a strongly calcareous mica-schist which, ecologically at least, resembles the Ben Lawers schist. The calcareous rocks outcrop extensively at 2,300-3,000 ft., and support a luxuriant vegetation reminiscent of that adorning the rich cliffs of the Breadalbane hills. Many of the calcicole and indifferent species so far named are in quantity, and in their particular habitats *Carex atrata, Cerastium alpinum, Poa alpina* and *Salix lapponum* are quite plentiful and widespread. *Dryas octopetala* is local and grows most abundantly on the Glen Douchary face. Some of the crags here are relatively dry and sun-exposed, and hold a few species which have not been found elsewhere on the range. Some of the *Dryas* ledges have good clumps of *Salix reticulata* and its frequent moss associate *Rhytidium rugosum,* and *Cardaminopsis petraea* is abundant. *Carex capillaris* and *Potentilla crantzii* are present very sparingly and the non-viviparous form of *Poa alpina* occurs with the type. A few of the rarer species, *Draba rupestris, D. incana, Poa glauca, P. balfourii* and *Saxifraga nivalis* occur in scattered places on several cliffs but favour the northerly corries.

Lofty, damp and gully-riven cliffs fall sheer from the summit cairn of Seana Bhraigh into the sheltered, north-east facing Loch Luchd Coire. Conditions here have favoured the survival of a few high montane species, and the corrie is the most northerly station so far known in Britain for *Gnaphalium norvegicum* (a calcifuge or indifferent species), *Phleum commutatum* and *Saxifraga rivularis.* All three are scarce. *Veronica serpyllifolia* ssp. *humifusa* luxuriates in wet gullies and flushes below the crags, and the same habitats, both here and in Coire Mor, yield *Juncus castaneus. Carex saxatilis* is locally abundant on adjacent hills immediately to the south but has not been noticed on Seana Bhraigh itself. Similarly, while *Cerastium arcticum* is plentiful on the cliffs of Beinn Dearg, the montane *Cerastium* of Seana Bhraigh appears to be all *C. alpinum.*

Two other species have only been seen away from the precipitous corries. *Deschampsia alpina* occurs in acidic stony flushes on the upper slopes and is strikingly abundant amongst eroding blanket-bogs in one place on the plateau east of Meall Glac an

Ruighe, here growing on the mixture of residual peat and underlying drift. *Tofieldia pusilla* is found in several flushes on gentle slopes of the hills between Seana Bhraigh and Eididh nan Clach Geala.

Ferreira (1958) has described the rich montane flora of Ben Hope in Sutherland, and showed that it is due largely to the presence of a thick band of strongly calcareous schist in the Moine granulite. The recent discovery of *Salix reticulata* and *Potentilla crantzii* (Ferreira, 1957) and subsequently of *Saxifraga nivalis* indicate that the possibilities of this hill are not yet exhausted, and *Minuartia rubella* has yet to be re-found.

Farther south, Ben More Assynt has perhaps been neglected in favour of the Inchnadamph limestone immediately westwards, but my own searches were amply rewarded. The upper part of this mountain is composed of Lewisian rocks, which are exposed as extensive ranges of cliff above Dubh Loch Mor and in the two east-facing corries. Much of the rock is strongly calcareous and supports a rich vegetation similar to that of the Seana Bhraigh corries. The east-facing corries at 2,700-3,200 ft. are the most productive in number of species. *Carex saxatilis* is abundant, both on moist rock-ledges and in little marshes beside flushes and rills lower in the corrie. In the first situation it is accompanied sparingly by *Deschampsia alpina* and in the second by *Juncus castaneus,* while on the moist and broken sides of at least one gully, *Juncus biglumis* is quite plentiful. These four plants are probably here in their northernmost British stations. *Saxifraga nivalis* is well scattered on the cliffs, with some fine plants, and good tufts of *Draba rupestris* occur here and there. *Draba incana* is rather rare. *Veronica serpyllifolia* ssp. *humifusa, Cerastium alpinum* and *Poa alpina* are abundant, and the non-viviparous form of the last was found. *Dryas,* so abundant on the adjacent limestone, was not encountered anywhere on these Lewisian crags, nor were any of the calcicolous montane willows. *Cerastium arcticum* was the only notable find on the adjoining quartzite hill, Conival.

No other hills in the Northern Highlands are quite as rich as the ones mentioned, but a few are good and some are still unworked. In West Ross the Lewisian mountains of Mullach Coire Mhic Fhearchair and Beinn Lair have extensive exposures of calcareous rocks which support most of the usual calcicoles.

Cardaminopsis petraea and *Cerastium arcticum* are plentiful on both hills. In addition, the first has *Carex atrata, Deschampsia alpina, Draba rupestris* and *Poa glauca*; and the second *Carex capillaris* and *Tofieldia.* Of the Moine hills, those in Glen Carron Forest have a few good exposures of calcareous rock, yielding *Saxifraga nivalis, Draba incana, Poa glauca,* and, in flushes, *Tofieldia pusilla.* The hills of the Monar Forest produced few calcicoles except the more common species, but Sgurr a' Chaora-chain yielded another Ross-shire locality for *Luzula arcuata.* Sgurr a' Mhuilinn on the south side of Strath Bran has some calcareous rock locally with *Salix lapponum, S. myrsinites, Tofieldia pusilla* and *Equisetum variegatum.* Some of the high corries of Fannich Forest are promising but the massive Ben Wyvis is composed largely of non-calcareous Moine schist, and though many calcifuge or indifferent species are strongly represented, there are few calcicoles. *Alopecurus alpinus* grows in the high level oligotrophic springs and flushes on this hill.

In Sutherland, Meall Horn is a fairly rich Moine hill, and in the east, the two Old Red Sandstone hills, Ben Griam More and Beag, have between them *Dryas, Potentilla crantzii, Cerastium alpinum, Cardaminopsis petraea* and *Draba incana* besides more usual calcicoles.

Several of the higher Torridon sandstone hills in both counties have somewhat calcareous cliffs with a luxuriant ledge vegetation, locally at least, but the more exacting calcicoles such as *Dryas, Polystichum lonchitis* and *Saxifraga oppositifolia* do not occur on this type of rock. The sandstone cliffs tend to be very wet and a few species grow on them in noteworthy abundance, as do *Cochlearia alpina, Saussurea alpina, Sedum rosea, Saxifraga stellaris* and *Armeria maritima.* The most productive Torridon sandstone hills for cliff plants are Liathach, An Teallach, Beinn Bhan in Applecross, Baosbheinn and Cul Mor.

Appendix.

The following species seem to be unrecorded for the particular vice-counties. The year in which the record was made is indicated in each case.

West Ross., v.c. 105.

Carex capillaris	Beinn Lair, 1956	Seana Bhraigh, 1957
C. atrata	Mullach Coire Mhic Fearchair, 1956	Seana Bhraigh, 1956
Salix reticulata	Seana Bhraigh, 1956	
Potentilla crantzii	Seana Bhraigh, 1957	

East Ross., v.c. 106.

All on Seana Bhraigh in September 1956.

Draba rupestris
Dryas octopetala
Juncus castaneus
Poa alpina
Poa glauca
Saxifraga nivalis
Saxifraga rivularis

East Sutherland, v.c. 107.

All on Ben More Assynt in June 1959.

Carex saxatilis
Cerastium alpinum (old record confirmed)
Draba rupestris
Deschampsia alpina
Juncus biglumis
Juncus castaneus
Poa alpina
Saxifraga nivalis

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NOTES ON THE SCOTTISH FLORA.

Flora of Jura II: List of Lichens.

The following list is based on collections made by D. W. Dresser, R. B. Knox and J. B. Wilson on the Edinburgh University Biological Society's Expedition to the Isle of Jura in June and July 1957. I wish to acknowledge the help and advice received from the Society's Cryptogamic Secretary, Mr. D. M. Henderson, whose encouragement persuaded me at least to scrape the surface of lichen taxonomy. My thanks also to Miss U. K. Duncan for determining the species of *Cladonia*.

Nomenclature and arrangement are based on: Watson, W. (1953), *Census Catalogue of British Lichens*. London.

Usnea comosa Oak/Birch woodland, on trunks, Inverlussa and Corrievreckan Sound.

Parmelia perlata Oak/Birch woodland, on trunks, Inverlussa and Corrievreckan Sound.

P. caperata Maritime rock crevices, near mouth of cave, Lussagiven; and oak/birch woodland on maritime slopes at Corrievreckan Sound.

P. laevigata Birch woodland, Inverlussa and Corrievreckan Sound.

P. saxatilis Birch scrub, maritime slopes, Corrievreckan Sound.

P. omphalodes Maritime rock crevices, near mouth of cave, Lussagiven; and Birch scrub, Corrievreckan Sound.

P. sulcata Exposed quartzite crevices on shore near Inverlussa.

Hypogymnia physodes Birch woodland, Inverlussa.

Menegazzia pertusa Maritime rock crevice near cave mouth, Lussagiven; Birch scrub on maritime slopes, Corrievreckan Sound.

Cetraria aculeata Upper slopes of Paps of Jura, 1,750-2,250 ft., dry slope on and amongst boulders.

Lecanora atra Exposed quartzite crevices, on shore at Inverlussa.

Ramalina scopulorum Exposed maritime quartzite crevices, Inverlussa; dry crack on quartzite cliff, maritime, north of Glengarrisdale Bay; edge of Birch scrub, on steep slope, Corrievreckan Sound.

Xanthoria parietina Exposed quartzite crevices on shore at Inverlussa; near large arch, on shore in North-West of Jura, bare rock.

Pseudophyscia fusca Exposed quartzite crevices on shore, Inverlussa.

Umbilicaria pustulata Damp ledge at base of cliff, large bay in North-West (Grid Ref. 17/687001); and edge of Rowan/Birch scrub, Corrievreckan Sound, on trunks.

Cladonia impexa Near arch, North-West of Jura (17/680005); dry rock cracks, North-West of Glengarrisdale; Oak/Birch woodland at Inverlussa and slopes at Corrievreckan Sound.

C. CERVICORNIS var. SUBCERVICORNIS Paps of Jura, Nardus-Molinia pasture, 1,000 ft.; steep slope on shore on Corrievreckan Sound, on trunks of Rowan and Birch.

C. POLYDACTYLA Oak/Birch woodland, Inverlussa and Corrievreckan Sound.

STEREOCAULON CORALLOIDES Dry rock cracks in cliff, in deep shade North-West of Glengarrisdale Bay.

LOBARIA SCROBICULATA Birch woodland, Inverlussa.

LOBARIA PULMONARIA Heavily-shaded Birch woodland, Inverlussa; Birch scrub on steep maritime slope, Corrievreckan Sound; on trunks.

L. LAETEVIRENS Amongst mosses at edge of birch woodland, Inverlussa.

PELTIGERA CANINA Eilean A'Bhorra, off Lussa Bay, maritime rock crevices.

PARMELIELLA PLUMBEA Crevices in rocks on shore pasture, near Inverlussa.

SPHAEROPHORUS GLOBOSUS Dry rock cracks in cliff, North-West of Glengarrisdale Bay; Oak/Birch woodland, Inverlussa and Corrievreckan Sound; maritime rock crevices near Lussagiven.

S. MELANOCARPUS Dry rock cracks in cliff-face, North-West of Glengarrisdale Bay.

R. B. KNOX.

KOENIGIA ISLANDICA IN MULL.

During a visit to Mull in July 1959 the reported locality for *Koenigia islandica* was examined in some detail and the species found to be widespread over a few square miles, occurring from 1,250 to 1,700 ft.

The Ardmeanach peninsula, to which the species is confined, consists for the most part of Tertiary Basalt lavas identical with those of Trotternish, Skye. In the north and east this rock forms an undulating plateau at about 1,500 feet and here there are considerable areas of gravelly rock detritus almost devoid of vegetation, with many flushed patches. In the damper places *Koenigia* is often abundant, associated principally with *Juncus bulbosus, Sagina subulata* and *Caltha palustris* ssp. *minor,* and in the drier places with *Oligotrichum hercynicum.*

The range of habitats occupied by *Koenigia*—flushes, drier gravelly places, semi-stable screes—is here the same as in Skye and the reddish rock and overlying soils are exactly similar. In other areas of Mull where these habitats are present, e.g. on the slopes of Ben More, the rock though geologically similar, appears to be harder and of a different colour, the soils have a lower proportion of fine particles and *Koenigia* is apparently absent.

The Ardmeanach peninsula has a particularly moist climate, lying as it does on the west side of the island, and low cloud is very frequent, perhaps even more so than some of the higher portions of the island further east. It is of particular interest that the normal lower limit of cloud seems to correspond to the lower limit of *Koenigia,* as was also noted by the author in Skye.

A further point of similarity to the Storr, Skye, locality is the presence of numerous well-marked stone polygons, particularly on the rounded summits of Maol Mhèadhonach and Beinn na Srèine.

DENIS RATCLIFFE.

CORRIGENDUM.

HABITAT OF KOENIGIA ISLANDICA IN SCOTLAND.
(Vol. **37**, Part 4.)

p 274, line 20 to read:
" . . . noteworthy that Godard (1958) records stone polygons on the . . . "
line 26 to read:
" . . . 'debris terraces' as Fitzpatrick (1958) terms them. Godard apparently . . . "

p. 275, additional reference:
Godard, A. (1958). Quelques observations sur le modèle des régions Volcaniques du nord-ouest de l'Écosse. *Scot. Geog. Mag.,* **74**, 37.

DENIS RATCLIFFE.

Report of the Cryptogamic Section, 1959.

By D. M. Henderson.

On the morning of Saturday, 9th May, about thirty members foregathered at the harbour at St. Abbs for what proved a very successful algological meeting. On the rocks above highwater mark the typical flora of situations exposed to considerable wave action was well represented with *Ascophyllum nodosum* the dominant species. Later in the morning, after due preparation, the highlight of the excursion came with the aqualung diving for weeds in the deeper waters of Sheep's Heid Hole by members of the Edinburgh Sub-aqua club led by Mr. W. Marshall. The richness of the sub-littoral flora, both in luxuriance of growth and in number of species, especially epiphytic Rhodophyceae, was well demonstrated by the many *Laminaria* stipes which were brought to the surface. After the divers had exhausted their supplies of air the party retired to Coldingham Bay for lunch and spent the afternoon searching the shores for cast algae, but without much success: a striking comment on the haphazard methods available for the investigation of the sub-littoral flora before the advent of the aqualung. In the course of the afternoon two interesting flowering plants were found: a basal rosette of the yellow Horned-poppy *Glaucium flavum* on the foreshore and strikingly vigorous hybrids between the cowslip and primrose on the steep grassy slopes.

For the annual autumn fungus foray about forty members of the Botanical Society and the Edinburgh Natural History Society met on Tynninghame Estate, on Saturday, 10th October, by permission of the Earl of Haddington. As a result of the extremely dry summer the dependence of the larger fleshy fungi on abundant supplies of moisture for successful fruiting soon became abundantly clear, for although the seashore woods of the estate were well searched very few fungi were found. Under these conditions, it was interesting to note which species could fruit. For instance, as might be expected, the fruiting of the conifer parasite *Fomes annosus* seemed little affected. Of agarics the only species in any abundance were the False Chanterelle, *Clitocybe aurantiaca,* and the Fairy Ring champignon, *Marasmius oreades,* both rather tough resilient species.

Prolonged search, however, yielded two of the fungi for which Tynninghame is particularly noted; the Earthstars *Geastrum rufescens* and *G. triplex*. On the salt marsh an interesting rust fungus, *Uromyces chenopodii*, was seen severely attacking the unusually abundant growth of the seablite, *Suceda maritima*. This fungus is known to have been present for several years at Tynninghame but its abundance in 1959 was probably due to the unusually high summer temperatures.

Report of the Alpine Section, 1959.

By J. Grant Roger.

DAY EXCURSION TO N.W. DUMFRIESSHIRE.

(20th June 1959.)

With the primary object of introducing students to the interesting montane flora of that part of the Southern Uplands in Dumfriesshire dominated by White Coomb (2,696 ft.) an excursion to the area traversed by the Tail Burn and the Midlaw Burn was arranged. The party, 23 in all, ascended from the valley of the Moffat Water to the crags by the Grey Mare's Tail and then by the upper reaches of the Tail Burn towards Loch Skene. Here, and on some of the neighbouring hills, the native Silurian rocks, which are calcareous in places, support a fairly rich flora of mountain species, quite outstanding for the Southern Uplands generally, as is emphasized by Dr. Derek Ratcliffe's important ecological account of the vascular plants and bryophytes of the area, entitled "Mountain Plants of the Moffat Hills" (*Trans. Bot. Soc. Edinb.*, **1959, 37,** 257).

Some time was spent in exploring the steep sides of the Tail Burn where the following were among the species noted on the damp slopes and ledges overlooking the burn from about 950 ft. to 1,300 ft. in altitude: *Alchemilla glabra, Ajuga reptans, Arabis hirsuta, Carex flacca, Geranium sylvaticum, Helictotrichon pratense, Hymenophyllum wilsoni, Leontodon hispidus, Luzula sylvatica, Oxyria digyna, Saxifraga oppositifolia, Sedum rosea, Thalictrum minus, Trollius europaeus* and *Vicia sylvatica.*

Proceeding upwards by the side of the Tail Burn to Loch Skene (1,680 ft.) the party divided, some ascending the slopes on the south-west side of the loch and others following the Midlaw Burn to the northern side of White Coomb and towards Donald's Cleuch Head. *Cryptogramma crispa, Dryopteris abbreviata,* and *Saxifraga hypnoides* were found on the steep scree slopes overlooking Loch Skene, and *Salix herbacea* on the higher more exposed places, mainly above 2,000 ft. Over the top part of the ridge between the loch and the head of the Midlaw Burn the common species included *Agrostis canina, Anthoxanthum odoratum, Calluna vulgaris, Festuca ovina, Eriophorum vaginatum, Galium hercynicum, Luzula campestris, Potentilla erecta, Rubus chamaemorus, Trichophorum caespitosum* and *Vaccinium myrtillus.*

The rocks about the head of the Midlaw Burn were found to be locally rich in calcicolous montane species and those favouring moist shaded crags generally. The following were observed between 2,000 and 2,300 ft.: *Angelica sylvestris, Arabis hirsuta, Botrychium lunaria, Carex atrata* (rare), *Rhinanthus borealis* (rare), *Salix lapponum* (rare), *Saussurea alpina, Saxifraga hypnoides, S. nivalis* (rare), *Sedum rosea, Selaginella selaginoides* and *Thalictrum alpinum.*

Time did not permit extensive exploration of White Coomb but a few members of the party traversed the upper slopes of the mountain, finding in some of the interesting high flushes *Epilobium anagallidifolium, E. alsinifolium* and *Alopecurus alpinus,* the latter being very local and having here its only known station in the South of Scotland. On the adjoining moorland *Chamaepericlymenum suecicum* was found in very small quantity.

DAY EXCURSION TO AM BINNEIN, PERTHSHIRE.
(18th July 1959.)

Am Binnein or Ben A'an (3,821 ft.) was approached by car via Balquhidder to Inverlochlarig from which the party, 11 in all, commenced the ascent of the mountain by the east side of Inverlochlarig Glen. The prominent plants in the glen between about 600 and 1,200 ft. included: *Agrostis canina, Anthoxanthum odoratum, Bellis perennis, Blechnum spicant, Carex binervis, C. pulicaris, Cerastium vulgatum, Deschampsia caespitosa, Drosera rotundifolia, Epilobium palustre, Euphrasia brevipila, Festuca ovina, Galium hercynicum, Holcus lanatus, Juncus acutiflorus* (locally abundant), *J. squarrosus, Linum catharticum* (local), *Luzula multiflora, Molinia caerulea, Narthecium ossifragum, Nardus stricta, Pedicularis palustris, Polygala serpyllifolia, Potentilla erecta, Prunella vulgaris, Pteridium aquilinum* (locally dominant), *Ranunculus acris, Saxifraga aizoides* (local), *Selaginella selaginoides, Thelypteris oreopteris, Thymus drucei, Valeriana officinalis* (local) and *Viola riviniana.* In the lower part of Inverlochlarig Glen drift material generally overlies the native schists and acid soil conditions usually prevail except, evidently, where basiphilous species such as *Linum catharicum* and *Saxifraga aizoides* occur. On the steep crags of Stob Invercarnaig, overlooking the lower part of the glen on the east side, *Asplenium adiantum-nigrum, A. trichomanes* and *Helictotrichon pratense* were found.

From the head of Inverlochlarig Glen the ascent of the south-west shoulder of Am Binnein was made by the south side of the Allt Dhaidh near the source of which, on wet crags, the following species were noted, at c. 2,600 ft.: *Armeria maritima, Deschampsia alpina, Parnassia palustris, Polygonum viviparum, Rubus saxatilis, Sedum rosea* and *Thalictrum alpinum,* while on the adjoining slopes *Alchemilla alpina, Anthoxanthum odoratum, Deschampsia flexuosa, Festuca ovina, Nardus stricta,* and *Vaccinium myrtillus* were commonly present. In this area *Rubus chamaemorus* occurred up to about 2,800 ft. and *Saxifraga aizoides* was local in stony places up to about 3,000 ft., at which elevation *Gnaphalium supinum, Juncus trifidus* and *Luzula spicata* became frequent.

The very exposed ridge leading northward to the summit of Am Binnein was reached at about the 3,300 ft. contour, where *Carex bigelowii* and *Salix herbacea* were conspicuous, along with *Rhacomitrium lanuginosum* and *Cerania vermicularis.* After attaining the summit, from which magnificent distant views were obtained, an hour or so was spent in exploring the nearby north-east facing crags of quartzose mica-schist on which the following were among the species noted:—

Vascular plants—*Alchemilla alpina, Carex bigelowii, Cherleria sedoides, Cochlearia alpina, C. micacea, Cryptogramma crispa, Deschampsia caespitosa, Draba rupestris, Epilobium alpinum, Festuca vivipara, Galium hercynicum, Luzula spicata, Lycopodium selago, Oxyria digyna, Poa alpina, Rumex acetosa, Salix herbacea, Saxifraga aizoides, S. hypnoides, S. nivalis, S. oppositifolia, S. stellaris, Sedum rosea* and *Vaccinium myrtillus.*

Mosses — *Amphidium mougeotii, Bartramia ithyphylla, Dicranum blyttii* and *D. falcatum.*

Liverworts—*Diplophyllum taxifolium, Nardia scalaris* and *Ptilidium ciliare. Drabra rupestris,* which has here probably its most southern station in Britain, appeared to be extremely local.

The descent of the mountain was made along the extensive ridge by Stob Coire an Lochan southward to Stob Invercarnaig and thence to Inverlochlarig. The phenomena of solifluction were strikingly evident on parts of the ridge, at ± 3,000 ft. where the vegetation commonly included *Alchemilla alpina, Deschampsia flexuosa, Festuca vivipara, Juncus trifidus, Salix herbacea, Oligotrichum hercynicum* and *Rhacomitrium* spp. Several fine specimens of *Amanitopsis nivalis* were found in association with *Salix herbacea* at 3,200 ft.

Committee for the Study of the Scottish Flora

Fifth Annual Report to 31st December 1959.

The Committee has met three times (at Perth in March and October and at Edinburgh in November) and, in addition, met officers of the two sponsoring Societies at Edinburgh in April. Two Exhibition Meetings were held: at the Museum and Art Gallery, Perth, by kind permission of the Director, on 21st March, and at the Royal Botanic Garden, Edinburgh, by kind permission of the Regius Keeper, on 7th November. There were two Field Meetings, one at Castle Douglas from 12th-15th June, led by Miss E. I. Biggar, and one on the Isle of Lewis and Harris from 1st-15th August led by Dr. F. H. Perring and Miss U. K. Duncan. The Committee also made the arrangements for the Annual General Meeting of the Botanical Society of the British Isles in April.

Much of the work at the Field Meetings was again devoted to the Distribution Maps Scheme; 14 members and friends attended at Castle Douglas, 9 at Lewis and 9 at Harris. Reports of these meetings will appear in the *Proc. Bot. Soc. British Isles.*

The Exhibition Meeting at Perth was attended by about 60. Professor J. R. Matthews delivered an illustrated lecture entitled "The Perthshire Flora—an Analysis" and, after discussion, he was thanked by Dr. Langlands, President of the Perthshire Society of Natural Science. The official exhibits of the sponsoring Societies were displayed, together with the following: Woodland Bryophytes from the Den o' Alyth (Dr. and Mrs. D. A. Robertson, Dundee); *Lemna trisulca*, a rapid coloniser of primary settlement tanks of sewage works at Scone; and *Petasites japonicus, P. fragrans* and *P. albus*, all introduced and established in a number of places (Botany section of the Perth Society); *Hapalosphaeria deformans*, a fungus causing malformation of *Rubus* spp., first recorded in Britain in 1907 and again in 1947 (Dr. Mary Noble, Edinburgh); *Leontodon autumnalis*, a comparison of the varieties *pratensis, sordidus*, and *simplex* (D. Ratcliffe and R. Knox, Edinburgh); Scottish Carices (Miss Ursula K. Duncan, Arbroath); Plant and Soil Succession on the Serpentine of Meikle Kilrannoch, Glen Clova (J. K. Marshall, St Andrews); Studies in serpentine soil infertility using serpentine soil from Unst, Shetland (Miss E.

Millar, St Andrews); Plants alien to Britain but naturalised and in many cases spreading (P. S. Green, Edinburgh). The Chairman of the Committee thanked the Director of the Museum and the members of the Perthshire Society, with whose co-operation the meeting had been held.

In Edinburgh the attendance was about 90, and the Chairman presided. Miss E. P. Beattie showed coloured slides of plants of the Edinburgh area, and Mr. D. McCosh exhibited slides of Scottish plants. The following exhibits were on view: Hybridization in British species of *Papaver* (I. McNaughton); Variation in British Birches (F. J. W. England); Ecological distribution of two races of *Festuca ovina* and a parallel in *Agrostis* spp. (Dr. Patricia Watson and D. J. Harberd); Clone-spotting in *Trifolium repens* (D. J. Harberd); Crop diseases and wild plants (Dr. Mary Noble and J. M. Todd); Some interesting Scottish aliens (Miss E. P. Beattie); Variation in *Leontodon autumnalis* (R. B. Knox); British plants said to occur in Pakistan (B. L. Burtt); Herbarium antiquities (I. C. Hedge); Plants from the Glass Houses (Royal Botanic Garden); and the exhibits of the two Societies. Mr. D. M. Henderson kindly acted as local organiser for this meeting.

At the Annual General Meeting of the Botanical Society of the British Isles in Edinburgh on 11th April the Regius Keeper of the Royal Botanic Garden and the Council of the Botanical Society of Edinburgh kindly afforded the Committee many facilities; arrangements were made for lectures to be given by Professor J. R. Matthews and Mr. J. Anthony, and for conducted tours of the Garden. A report of this meeting has appeared (*Proc. Bot. Soc. British Isles,* 1959, **3**, 350).

In April the Botanical Society of the British Isles appointed Dr. N. M. Pritchard a member of the Committee in place of Dr. G. Taylor and, in November, when Professor Matthews resigned, the Botanical Society of Edinburgh appointed Mr. P. S. Green to fill the vacancy. Professor Matthews has been closely associated with the Committee since its first meeting in 1955, and the Committee is very sensible of the debt it owes to this distinguished student of the Scottish flora, and very much regrets that the formal connection is now severed. Mr. R. MacKechnie was reappointed Chairman and Mrs. E. M. Elder Field Secretary. It has not yet been possible to find a Meetings Secretary, but Messrs D. M. Henderson and J. Grant Roger have agreed to share the work for the time being.

The accounts showed a deficit of £13 13s. 2d. for the year 1958, and this has been refunded by the two Societies. The average cost of the Committee to each of the two Societies for the four years has been £2 per annum, plus the cost of printing the programme. The deficit of 1958 is accounted for by the reduction in the number of field meetings and hence of booking fees received, together with an additional number of Exhibition Meetings.

The Committee adheres to its conviction that educational work, which cannot be accomplished without the spending of money, is one of its most important tasks and that in this way new members may be found for both Societies.

During the year the Committee agreed to accept, in due course, responsibility for housing a set of Scottish Master Cards for the Distribution Maps Scheme. Through the courtesy of the Council of the Botanical Society of the British Isles the Committee was able to examine and comment in detail on the proposals for revised rules of that Society.

The Committee is deeply indebted to individuals mentioned in the course of this Report, to the officers of the two sponsoring Societies, and also to others too numerous to list separately. Grateful thanks are expressed to everyone who has helped in any way during the year.

B. W. Ribbons, Honorary Secretary.

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